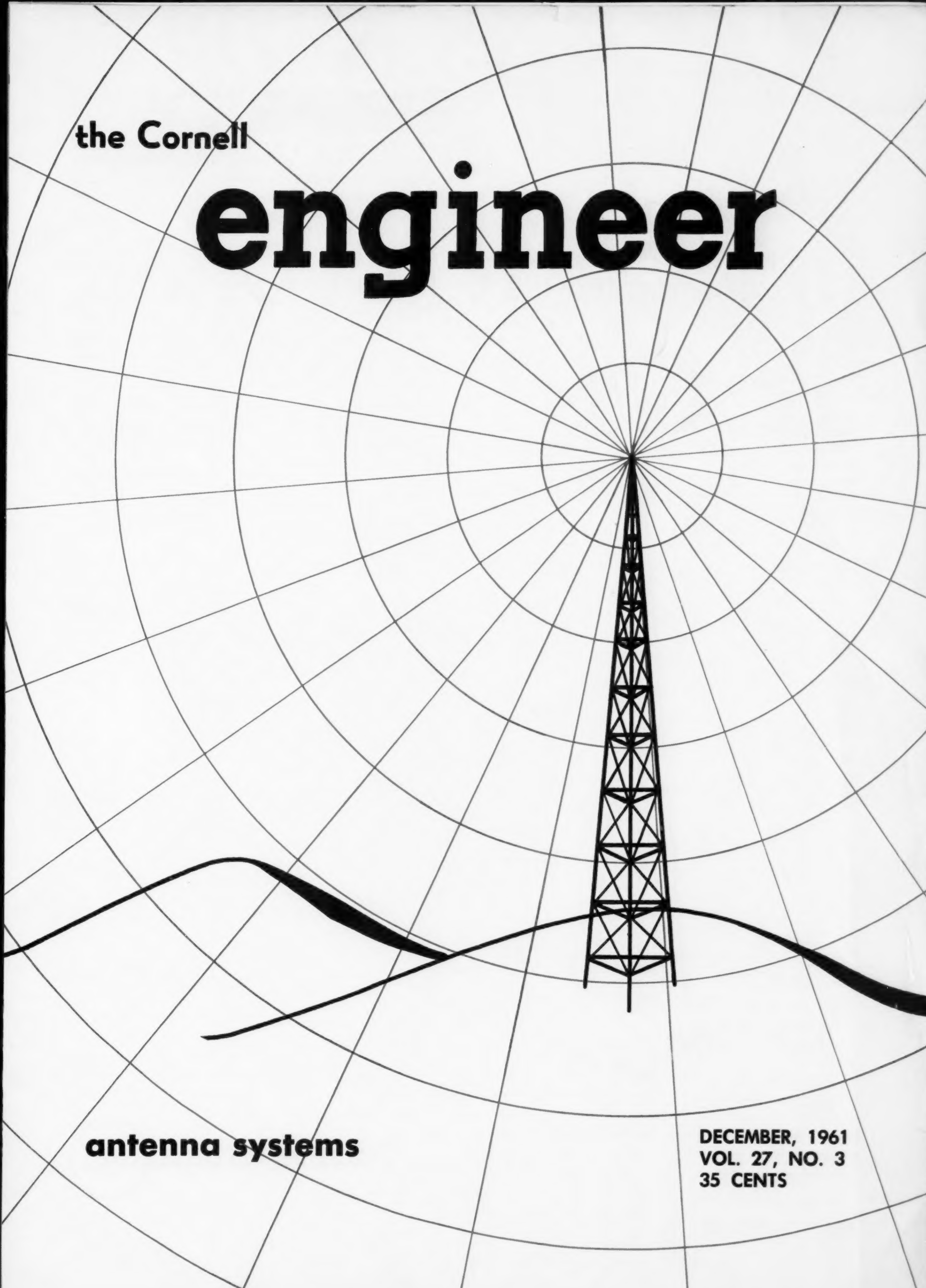
the Cornell

engineer



antenna systems

DECEMBER, 1961
VOL. 27, NO. 3
35 CENTS

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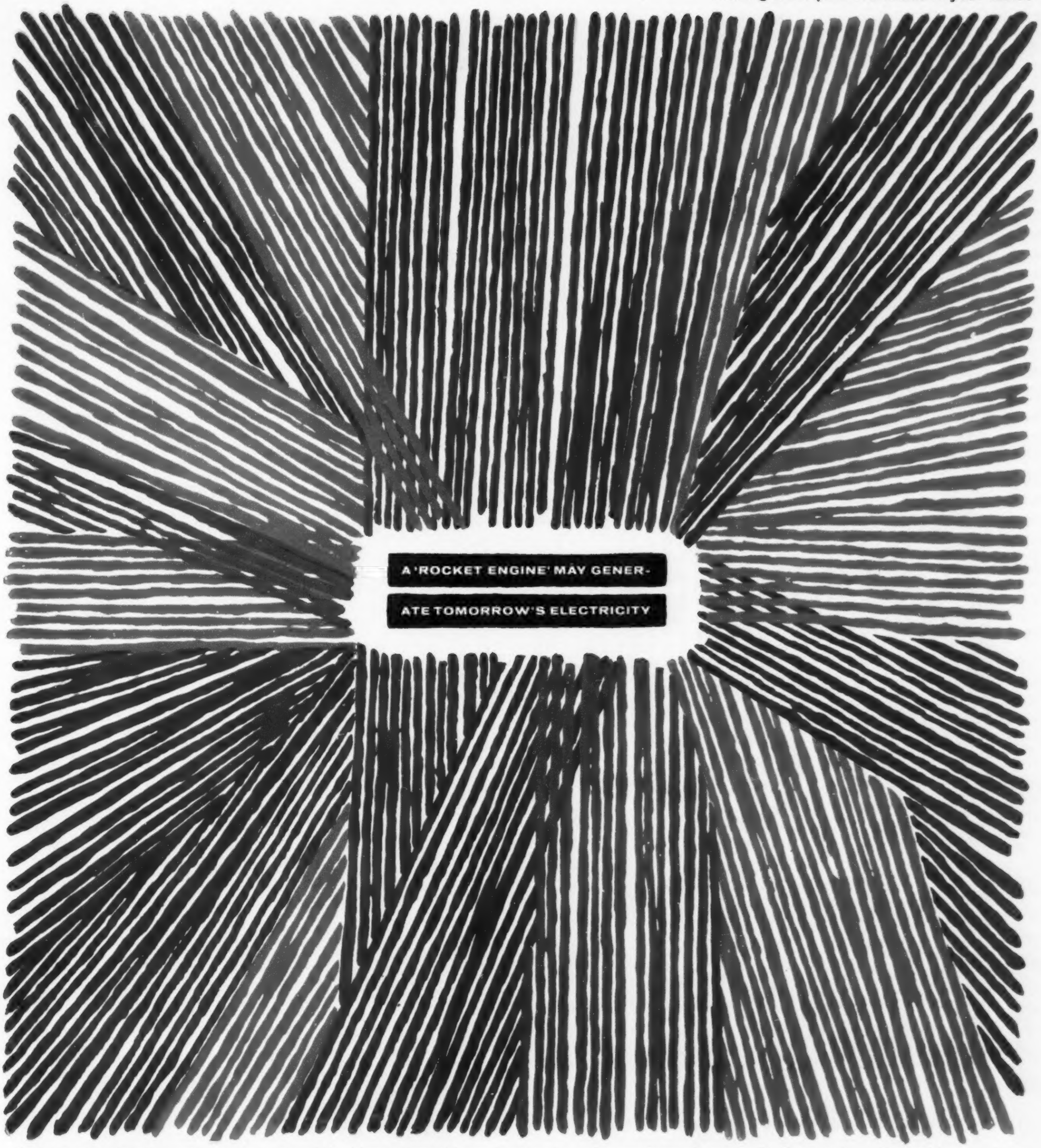

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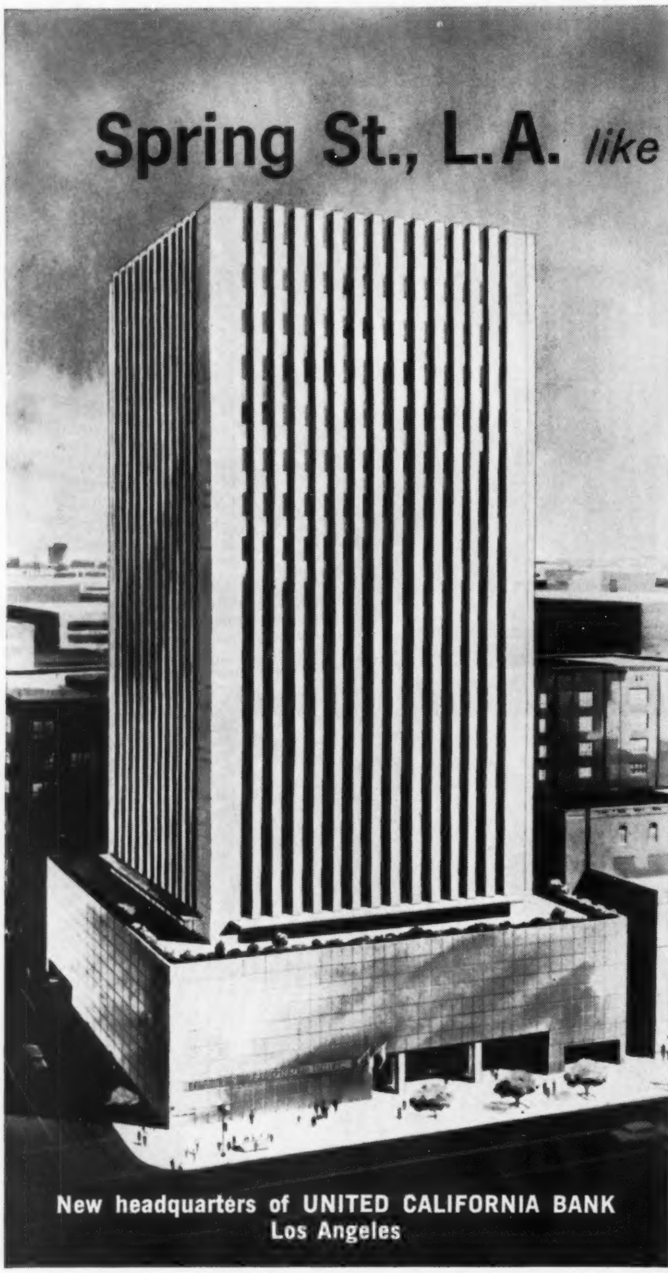

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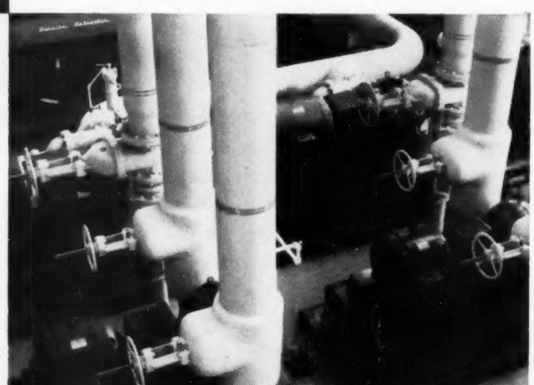

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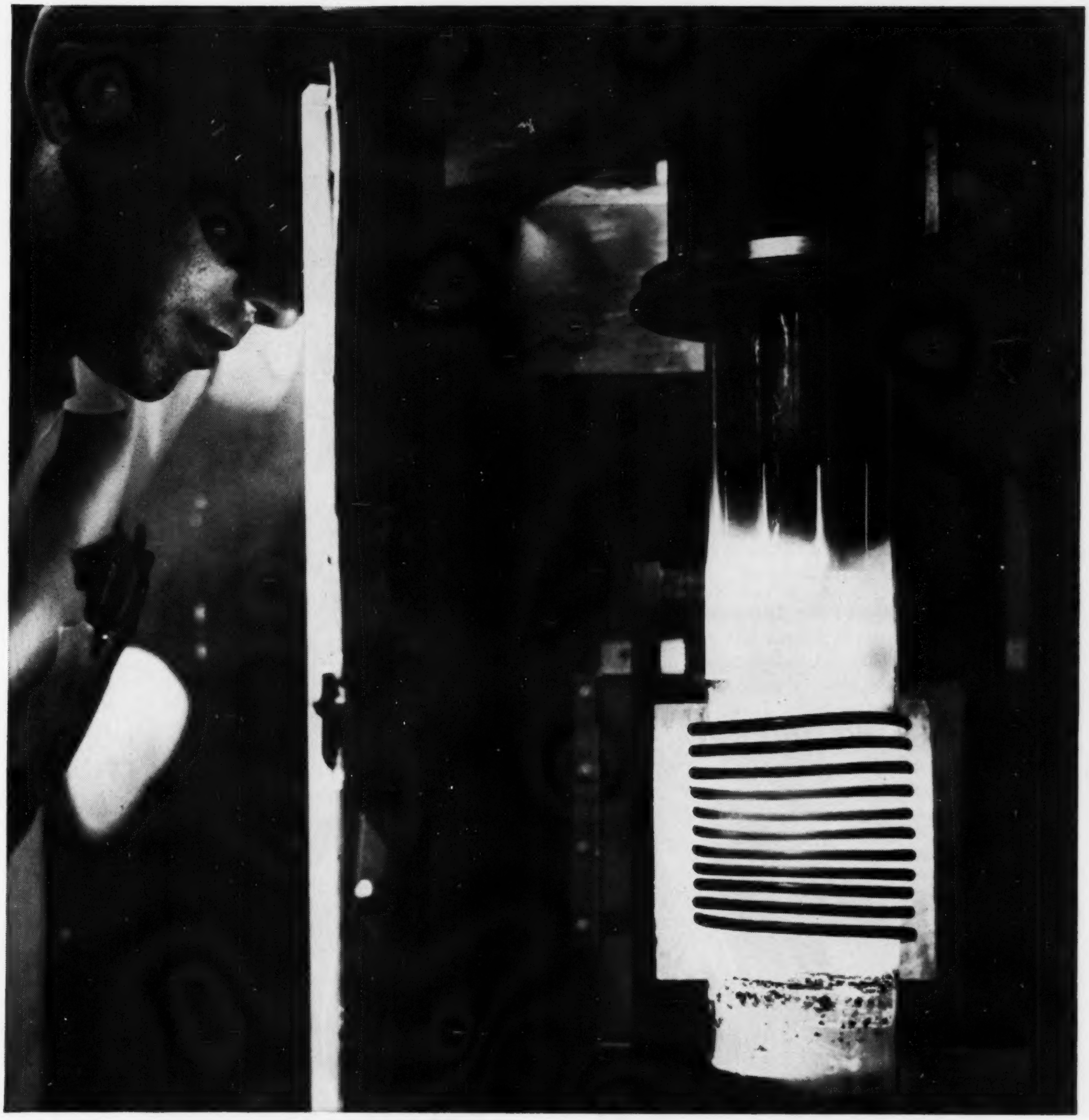

Founded in 1885

THE CORNELL

engineer

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COVER represents the role of the transmitting antenna. See article on Antenna Systems, page 28.

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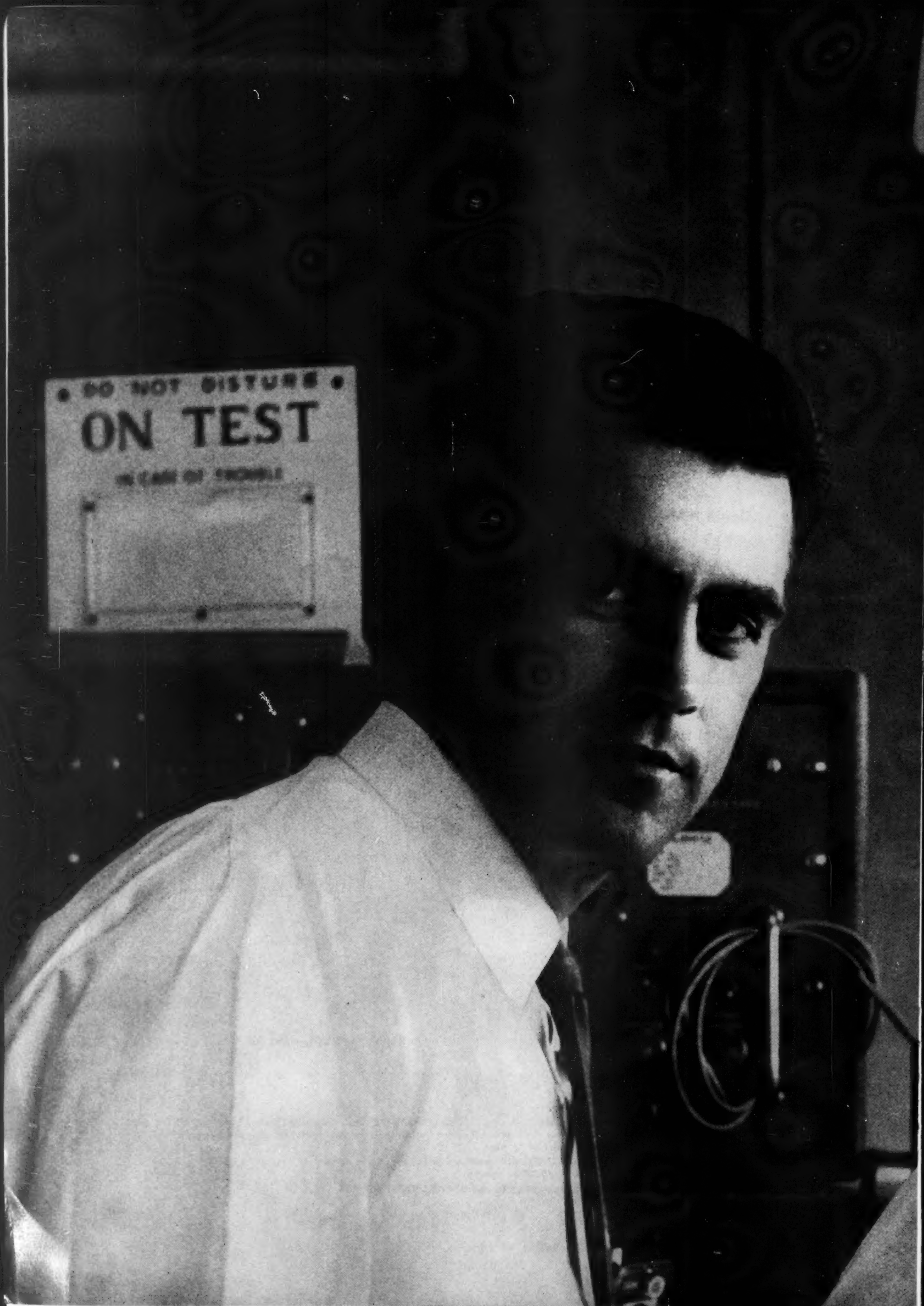
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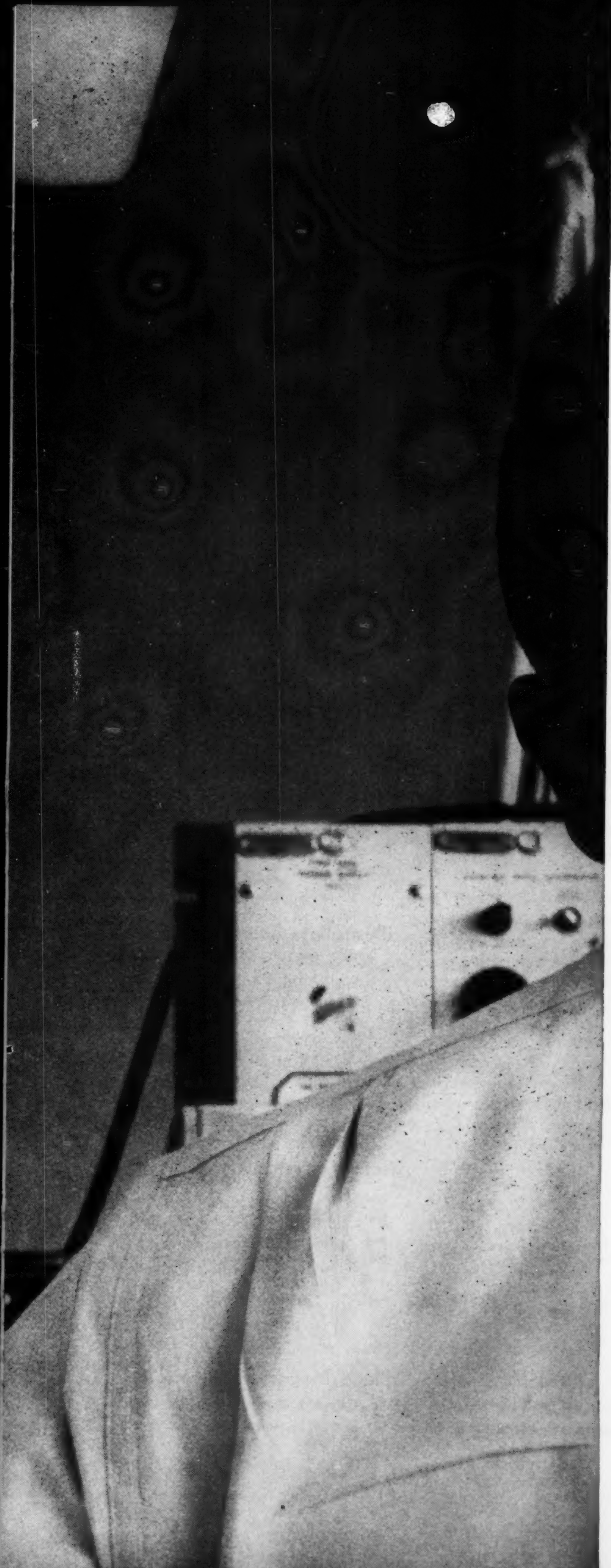

the Cornell **engineer**

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Editorial . . .

Engineering Education: Are We Doing All We Can?

There have been many changes and experiments in engineering education in the twentieth century. Some innovations, such as new curricula in engineering physics and industrial engineering, have been highly successful. Other proposals have not met with wide acceptance. Still other experiments, such as the five-year program and the "Division of Basic Studies" idea, are still being evaluated.

Recently, another change has been proposed. After operating throughout their histories on two-semester, summer-recess school years, colleges throughout the nation are considering a significant plan: a three-semester (trimester) school year, with a fourth semester offered during the summer. Some colleges have already adopted this type of schedule. For engineering colleges, in particular, this plan represents an exciting possibility.

The trimester schedule that engineering schools might adopt would require students to take an average of four courses per semester. A semester would contain ten or eleven weeks with, correspondingly, a three or two week recess between semesters. Regular full-time students would only be required to attend three semesters a year.

The advantages of a trimester program have been cited often. The utilization of physical facilities during only two-thirds of the year has been termed "a great tragedy" by many educators. It is deplorable that classrooms are idle during summer months. It is even more deplorable that equipment costing millions of dollars is only partially used, in the nation's engineering colleges, during this period. In order to insure that we are making full use of our resources to bolster our defense effort and strengthen our economy, it is mandatory that college and university facilities be used at all times.

For both students and faculty members, the trimester plan offers excellent possibilities. Students would have fewer courses on which to concentrate. It is difficult, for many engineering students, to give attention to six or seven courses simultaneously. Many feel that they are "spreading themselves thin." That is, they have neither time nor energy for profound examination of the principles taught in their courses. Almost all engineering students would welcome the opportunity to take fewer courses because they could apply themselves better and thus gain more from each subject.

As for faculty members, many would welcome the opportunity to remain active throughout the year. (Many, of course, desire the "change of pace" or "change in scenery" that the summer offers.) In addition, faculty members would receive more undivided attention from students taking fewer courses.

Much of what has been offered here has been said before. The most important advantage of a trimester program in engineering schools, however, has been lightly treated, if not overlooked entirely. The installation of trimester programs could have a marked effect on the place of cooperative programs in engineering education.

Cooperative education was originated in 1906 by Dean Herman Schneider of the College of Engineering at the University of Cincinnati. Since then, many wonderful, worthwhile experiences have been had by students participating in cooperative programs. Despite this fact and the fact that such plans are heartily endorsed by educators and representatives of industry, cooperative education is not enthusiastically accepted by today's engineering students. The primary reason for participating in cooperative plans is, for a large number of engineers, the remunerative benefits that are received.

That cooperative students do accrue educational advantages is confirmed by a national Study of Cooperative Education sponsored by the Thomas Alva Edison Foundation. The study group reported that "theory and practice are more closely integrated, student motivation is increased . . . (that) work experience contributes to a greater sense of responsibility."

These are important educational advantages. Why do so few students participate in cooperative plans? There are many reasons, but some of the reasons most often given by students are: that a summer job is just as good; that study in the summer is difficult and that very few courses are offered during the summer (Cornell, R.P.I., and M.I.T. offer summer engineering semesters for students who work in industry during the spring or fall terms).

A summer job, of course, is rarely "as good," and study during the summer isn't difficult *if* others are also studying, and many courses are offered *if* there are many people enrolled during the summer.

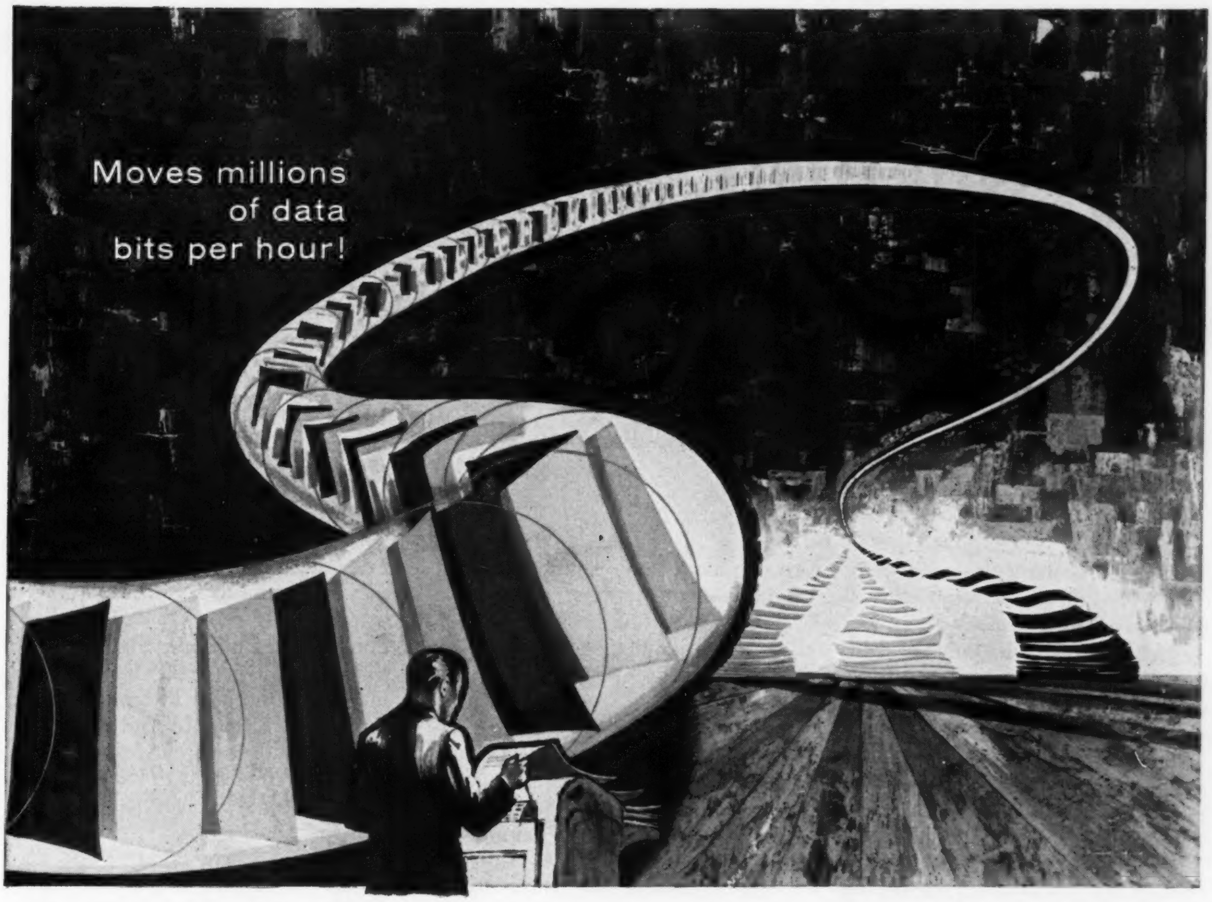
The engineering cooperative programs, therefore, would be viewed in a new light by students if courses were offered during the entire year. Participating students could work during any one of the four yearly semesters. More students would be working throughout the entire year. The large work force of students during the summer would potentially be reduced to one-quarter of its present number. The term "summer job" might no longer be used. This is a description of the conditions that would exist if colleges operated on a trimester basis.

Is participation by large numbers of students in cooperative programs critical in helping us attain national goals? The importance of such plans in accelerating the professional growth of the nation's engineers cannot be overlooked.

It is not out of order to remind ourselves of two facts. Our country's engineers have tremendous responsibilities and there is a scarcity of trained engineers. The National Science Foundation estimates that the average annual demand for the remainder of the decade is 81,000 engineers a year. The *New York Times* reports "that 1965 will see only 32,000 new engineering graduates.

In light of these facts, it is important that we carefully consider the proposal for using our colleges during the entire year. Once again we ask ourselves: "Are we doing all we can in engineering education?"

—KESSLER



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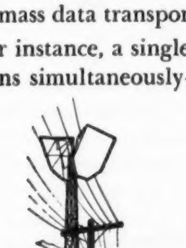

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NURTURER OF RESEARCH

— THE NATIONAL SCIENCE FOUNDATION

by David S. Kessler, ME '62

"While searching for methods of cooling re-entry vehicles a Cornell University mechanical engineer . . . discovered that heat transfer by natural convection may be stopped by spin.

"As a result of the find . . . the National Science Foundation has made a grant of $72,100 so that Professor David Dropkin can continue to direct the research."[1]

This news report from the *Cornell Engineer* is significant for two reasons. First, without this grant it would be almost impossible for Professor Dropkin to continue his important work. Second, the amount of money granted to the Cornell professor represents almost exactly one-third of the total amount of money appropriated to the NSF by Congress in 1950,[2] the year of the Foundation's inception.

Both of these facts attest to the tremendous progress made by the NSF in its first ten years of operation. They give no hint, however, of the tremendous five-year debate which preceded the passage of the National Science Foundation Act of May, 1950.

The idea of a National Science Foundation was first talked about during World War II. Many scientists noted that the United States war effort was hampered by a lack of coordination in the areas of engineering and scientific research. It was not until Dr. Vannevar Bush, Director of the Office of Scientific Development and Research filed a report in July, 1945 that the idea of such a foundation gained national atter tion. Dr. Bush strongly recommended the establishment of a permanent national science research foundation.[3]

No positive action was taken on the idea of a foundation until Senators Magnuson of Washington and Kilgore of West Virginia introduced a National Science Foundation Bill in the 79th Congress. The bill passed the Senate, but failed to gain necessary support in the House.[4]

The failure of the House to act favorably on the bill prompted the Washington *Post* to remark that "Failure to establish a National Science Foundation must be ranked high among the grievous sins of omission of the 79th Congress. Guilt rests, in this case, exclusively with the House of Representatives."[5]

Because of the adverse reaction of scientists and government officials alike, the idea for a NSF bill was not dropped. In fact, Senator Smith of New Jersey introduced another NSF bill, on behalf of himself and several other senators, on February 7, 1947.[6] The bill passed the Senate and went to the House for consideration. The House Committee on Interstate and Foreign Commerce immediately set up a series of hearings on bills relating to a National Science Foundation.

One of those who testified before the committee was Edmund Ezra Day, President of Cornell. President Day, who was also Chairman of the Inter-Society Committee on Science Foundation Legislation, a group of 68 National Scientific and Educational organizations, noted that his committee was interested in promoting the Science Foundation Project "because the committee is fully convinced that it is of utmost importance to the national interest to stimulate and promote fundamental research, and that it is equally important to increase the flow of trained scientific personnel."[7]

President Day said that his group had agreed there were four fundamental issues regarding the NSF Bill.[8]

The first was that fundamental research should be emphasized, as distinguished from applied and development research.

Secondly, the Society felt that a great deal of administrative freedom should be given to the new organization.

The third recommendation of the Society dealt with the subject of trained scientific personnel. President Day said that the new organization should make an effort to increase the flow of such personnel.

The fourth recommendation was that the new organization "should be charged with responsibility for the coordination of scientific research and effective utilization of personnel already available."[9]

Other prominent educators and scientists gave similar testimony. The House Committee apparently was favorably impressed over the need for such an organization because the NSF bill was passed by the House soon after the Hearings.

But the NSF was not yet destined to take its place as an inde-

pendent agency. President Truman vetoed the bill, saying in part:

> "... this bill contains provisions which represent such a marked departure from sound principles for the administration of public affairs that I cannot give it my approval.... It would, in effect, test the determination of vital national policies, the expenditures of large public funds and administration of important government functions to ... private citizens. The proposed National Science Foundation would be divorced from control by the people to an extent that implies a distinct lack of faith in the democratic processes."[10]

Truman ended his message by noting that "this work [for scientific research and development] is vital to our national welfare and security, and we cannot afford to jeopardize it [this work] by imposing upon it an organization so likely to prove unworkable."

Thus the bill was vetoed because the board of 24 men was empowered to appoint the director of the NSF and to distribute grants among colleges and universities.

Little action was taken on the bill during the remaining months of 1947. On January 4, 1950, President Truman, in an attempt to accelerate action on the bill, said in his State of the Union Address:

> "To take full advantage of the increasing possibilities of nature we must equip ourselves with increasing knowledge. Government has a responsibility to see that our country maintains its position in the advance of science. As a step toward this end Congress should complete action on the measure to create an NSF."[12]

"Congress should complete action. . . . " this was easily said. However, another House battle over the bill still loomed in the future.

On March 1, 1950, the House of Representatives resolved itself into the Committee of the Whole for what was to be a crucial consideration of the NSF bill (H.R.4846).[13]

The tone of the debate was set by the very first person to speak. Representative Fulton offered two amendments which would change the wording of several clauses in the bill. These amendments were agreed to, but Representative Fulton's proposals touched off a string of similar amendment proposals. Some were accepted; some were rejected.

Finally Representative Wolverton, who was a bit ruffled by the proceedings, stood up in opposition to an amendment "so he might have an opportunity to bring to the attention of the Committee some facts that had been overlooked. . . . "[14] He noted that this was the fourth time in four years that the bill had been offered.[15] He lightly rebuked members who were offering amendments when they had had ample opportunity to give ideas when the Committee was first drawing up the legislation.[16]

Representative Wolverton asked that the pertinent *Hoover Commission Report on Scientific Activities* be incorporated into the record. The following excerpts show why an NSF is so vital to the United States Government.[17]

The Commission noted that the Federal Government was engaged in a wide range of research activities involving tremendous expenditures ($625,000,000 in 1947). It further took note of the fact that a satisfactorily correlated research program had not yet been established.

In order for a research program to be effective the development of such a program "must have roots in every department with major responsibilities." The Commission stressed that there must be an organization which would coordinate the entire research activity of the Federal Government; the individual efforts of various agencies aren't enough.[18]

The Hoover Commission further recommended that the recommendations of the President's Scientific Research Board be heeded. That board had proposed the establishment of an Interdepartmental Committee on Scientific Research and Development. Such a committee was established in December, 1947. Its duties consisted primarily of furthering research activity in the Federal Government, but it did not meet its potential, according to the Hoover Commission Report. Because of its interdepartmental nature, this Committee never achieved adequate coordination.[19]

The Hoover Commission set forth its recommendations:[20]

(a) The Foundation should "examine total scientific research of the nation and should assess the role of the Federal Government in this effort."

(b) The NSF should be given "appropriations for the support of basic research and for research fellowships."

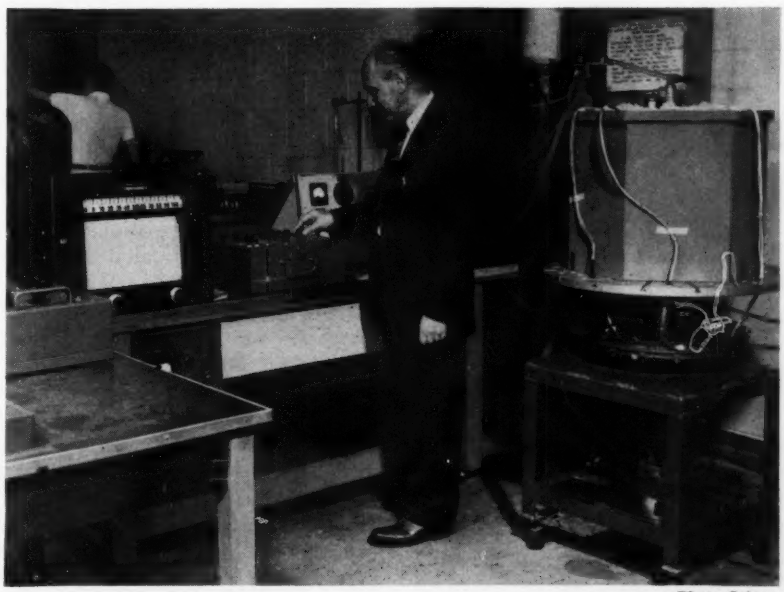


Photo Science

Professor David Dropkin has made significant discoveries as a result of experiments on the "Effect of Spin on Natural Convection in Liquid Metals Heated from Below." This project is sponsored by the National Science Foundation.

(c) The NSF should "advise the President as to the proper balance among research grants and fellowship programs supported by appropriations given to other federal agencies and as to major policies that should govern the administration of these programs."

After the reading of the Hoover Commission's Report, discussion on the bill dwindled until, after a motion to recommit the bill to the Committee on Interstate and Foreign Commerce was defeated, a final role call was taken. The long struggle over the bill came to an end as the NSF Act was passed by the House by a two to one margin. Notable among those voting "nay" was Rep. John Taber of Auburn, New York who had opposed the bill from the time the idea of a NSF had been first conceived.[21] The Senate had yet to vote, but it was expected that that body would pass the bill with little delay.

The New York *Times* of March 1, 1950 gave much attention to the security safeguards around the proposed NSF. The *Times* article reported that the Federation of American Scientists protested that one of the bill's amendments violated "a fundamental principal [sic] of science, that research must be free from political qualifications."[22]

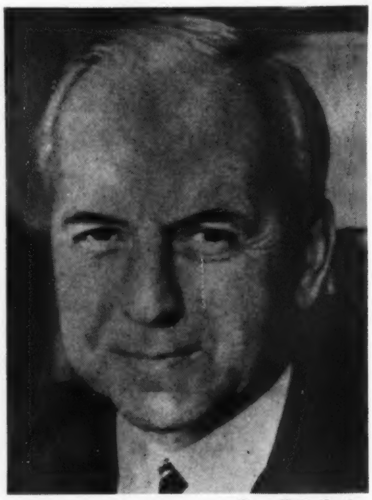
Almost unnoticed and just barely mentioned in the article was an amendment that was later to bring about much debate. Money allotted to the NSF was to be limited to $15 million a year.[23]

The security restrictions, perhaps the most controversial part of the bill, came under heavy fire from the Department of Justice some two weeks after the bill was passed by the House. The Department opposed Rep. Howard Smith's provision that no person "shall receive a scholarship or be employed by the NSF until the F.B.I. has investigated and reported the subject to be loyal. . . ."[24] The Justice Department apparently felt it had enough to do without having to police employees of the NSF.

The New York *Times*, editorializing on the subject of security, noted that "scientists and government officials disapprove of the length to which the proposed loyalty check goes. . . . It would seem adequate to engage a scientist or clerk on the basis of his character or competence because the NSF will not primarily be conducting research in classified fields, but will be doing research that will benefit industry and the country as a whole."[25]

The bill was passed by the Senate on March 18, 1950.[26] President Truman's signature was expected because the matters to which he had objected had been compromised.

But before the bill could be sent to the President, an old thorn interfered: the security issue. The task of solving the problems in this area was laid before Senate and House conferees. On April 5, 1950 they issued their final agreement.[27]



Cornell Daily Sun

President Edmund Day of Cornell: " . . . it is of utmost importance to the national interest to stimulate and promote fundamental research. . . "

1. Prospective Foundation employees and recipients of Scholarships who would have access to information concerning national security should be investigated thoroughly by the F.B.I.
2. The F.B.I. would report its findings to the Foundation without evaluating them.
3. Rules for employment or scholarship in classified areas would be as rigid as those applying to entrance into the atomic energy field or military service.[28]

Despite the extensive effort on the part of many people to make the bill a good bill, the New York *Times* poked at the bill, saying it "is not a perfect piece of legislation."[29]

President Truman signed the bill on May 10, 1950, the establishment of the National Science Foundation as "a major landmark in the history of science in the United States. Its establishment," Truman said, "climaxes five years of effort on the part of the Executive Branch, the Congress and leading private citizens. The nation's strength is being tested today on many fronts. The National Science Foundation faces a great challenge to advance basic scientific research policy. Its work should have the complete support of the American people."[30]

Laws Under Which NSF Operates

The NSF operates under a set of laws which permits it to exercise extensive control over the scientific activities of the United States Government.

The Foundation was established as an independent agency consisting of a National Science Board and a Director.[31]

The NSF has nine functions:[32]

1. "To develop and encourage the pursuit of a national policy for the promotion of basic research and education in the Sciences."
2. "To initiate and support basic scientific research in the mathematical, physical . . . and other sciences by making contracts or other arrangements [grants, loans] for the conduct of such basic scientific research. . . ."
3. ". . . to support specific scientific research activities in connection with matters relating to national defense. . . ."
4. "To award scholarships and fellowships in mathematical, physical, biological and other sciences."
5. "To foster interchange of scientific information among sciences in the United States and foreign countries."
6. "To evaluate scientific research programs by agencies of the Federal Government and to correlate the Foundation's scientific research programs with those undertaken by individuals. . . ."[33]
7. "To establish special commissions as the Board may from time to time deem necessary."
8. "To maintain a register of scientific and technical personnel in the United States."

9. "To support a program of study research . . . in the field of weather modification."

The NSF, in this writer's opinion, is organized for flexibility, simplicity and for "just plain getting things accomplished." The NSF consists of four main bodies.

The National Science Board is appointed by the President ". . . to provide representation of the views of scientific leaders in all areas of the nation."[34] The Board is charged with developing a research and education policy; determining the impact of research on industry; handling exchanges of scientific information, both within and outside of the United States; and with the previously mentioned function of coordinating the research of other agencies.[35]

The Divisional Committe advises the Board of Directors on matters relating to particular divisions.[36]

The body that advises the Divisional committee on the Scientific Merit of Research proposals is called, appropriately enough, the Advisory Panels. There are 24 panels in this body.[37]

The last sub-group of the NSF is the Interdepartmental Advisory Committee for Development of Scientists and Engineers. This body acts as a "liaison" with the National Committee for Development of Scientists and Engineers and "assists the NSF in its related responsibility for providing coordination of Federal efforts in programs in education and in sciences."[38]

Early Atmosphere Under Which NSF Operated

During the first year of operation of the NSF, the atmosphere under which it operated was one of frustration. Congress had given its "new baby" its blessings but hadn't given it enough funds to cover more than administrative expenses.[39] After a year of operating under this handicap, the National Science Board declared "that the failure of Congress to provide funds for the operation of the NSF will have disastrous consequences for the sound future development of our nation, which depends so heavily on science and technology."[40]

Dr. James Conant of Harvard, head of the Board warned that "failure to support [fundamental] research will handicap development of our industrial and military strength and greatly threaten our future national security and welfare."[41] How right he was, for "Sputnik" was launched just seven years after this warning!

The New York *Times* commented on the situation: "The working of the congressional mind is sometimes mystifying. . . . After all the testimony by distinguished military and naval officers and by scientists it seems incredible that the President's request has been shelved."[42]

Cornell Daily Sun

President Harry S Truman: "Government has a responsibility to see that our country maintains its position in the advance of science."

The financial plight of the Foundation did not go unattended. On November 4, 1951, Alan T. Waterman, the director, announced that the House and Senate had granted $3.5 million to the Foundation. President Truman had asked for $14 million.[43]

With the financial problem temporarily settled the NSF got down to work. Its first major report was delivered to Congress on January 15, 1952. The Foundation reported to Congress its general plans for "speedily placing the nation's research and development programs in a state of 'operational readiness' for possible war or an extended period of preparedness perhaps lasting many years."[44]

During 1952 and 1953 the Committee demonstrated that it could capably handle the functions prescribed to it. As a result, the duties of the NSF were expanded in 1954 by an Executive Order on the Administration of Scientific Research. The NSF was directly affected by the Order's Seven Sections. In addition, the Foundation's relationship with other agencies was clarified.[45]

Section 1: "The NSF shall from time to time recommend to the President policies for the Federal Government which will strengthen the national scientific effort and furnish guidance toward defining the responsibility of the Federal Government in conduct and support of scientific research."

Section 2: The NSF shall "make recommendations and studies regarding the nation's scientific research effort. . . ."

Section 3: The Foundation, in concert with each Federal agency concerned, shall review scientific research programs and activities of the Federal Government in order to formulate methods for strengthening the administration of such programs . . . by the responsible agencies . . . and shall recommend to the heads of agencies concerning the support given to basic research."

Section 4 stipulates that basic research by other agencies is "important and desirable and shall continue."

Section 5 states that the NSF, after studying the effects of university grants, "shall recommend policies which promote attainment of general national research objectives and realization of the research needs of Federal agencies while safeguarding the *strength and independence*[46] of the nation's institutions of learning.

Section 6 requires the head of each Federal Agency to consult the Foundation on research policies and Section 7, which has had widespread effects, asks the NSF "to make an effort to improve the classification and reporting of scientific research projects."

The NSF continued to warn the nation against the dangers of laxity in stimulating research. In its fourth annual report, the Foundation reported "an acute need for more widespread knowledge in the United States of Russian scientific advances." American physicists,"

the NSF added, believed there was a national danger of underestimating the strength of the Soviet Union."[47] To emphasize these remarks the Foundation announced it had requested increased translations of Russian scientific works.[48]

Recent Years

In order to gain a picture of the climate under which the NSF has been working in recent years it is necessary to investigate the efficacy of the Executive Order of 1954.

As was pointed out previously, the Executive Order was designed to end disagreement about the proper relationship between the Foundation and other agencies that had scientific interests. But disagreements have continued![49]

Some people would have liked the Order to have armed the NSF with stronger control measures over the scientific activities of other agencies. Despite the lack of really rigid controls, the Foundation does maintain a working relationship with these other agencies. For instance, an NSF staff member assigned to a project is aware of any other research (by other agencies) in his field being supported by the Government. This information aids the Foundation in determining what the distribution of support for certain sciences should be.[50] The task of the NSF is to distribute support evenly among various sciences. To do so it must know the exact amount of support being given to various sciences by other agencies.

In recent years the Foundation has continued to be the Government's chief advisor on scientific matters. It is not certain how extensively the Foundation has been called upon in its advisory capacity, however.[51]

The size of the appropriation for the NSF in the 1960–61 budget gives a clue to the tremendous progress made by the NSF in recent years. The total amount appropriated for 1960 was $154,773,000. It is estimated that the 1961 budget will show an appropriation of $190 million.[52]

Of the total amount appropriated for 1960 approximately $88 million went for support of science through grants and contracts. This figure represents the largest percentage of funds applied to any single program. By the end of this year approximately 1900 research grants and 3761 fellowships will have been awarded. In addition 31,325 science and mathematics teachers will have participated at NSF Institutes.[53]

"Clientele"

The types of people that the Foundation comes into contact with are numerous. "The Foundation," according to the 1960–61 budget, "supports basic research, pre and post doctoral fellowships, education in the sciences and interchange of foreign and domestic science information.[54]

The NSF supports scientific manpower by granting fellowships to graduate science students, college science faculty fellowships and other fellowships. It supports summer study programs for graduate teaching assistants and summer inservice institutes for the training of elementary, secondary school, and college teachers of science and mathematics.[55]

One of the NSF's most important services to its "clientele" is the maintenance of a national register of scientific and technical personnel.[56]

In the first ten years of operation the NSF has done what it was set up to do and more. It has expanded until, as was seen earlier, its influence is felt everywhere, even at Cornell.

There is no need to recount the details of the technological race with Russia. Let it suffice to say that the continually expanding NSF is coordinating the United States effort in engineering and scientific research.

FOOTNOTES

1. *Cornell Engineer,* November 1960; pg. 50.
2. The amount of money appropriated by Congress was $225,000.
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8. *Ibid.*
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12. New York *Times,* Jan. 5, 1950, pg. 10, Col. 7.
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16. *Congressional Record,* Vol. 96, part 2.
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30. New York *Times,* May 11, 1950, 24:2.
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34. "Advisory and Coordinatory Mechanisms for Federal Research and Development," 1956–57, NSF 57-13, U.S. Government Printing Office.
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41. *Ibid.*
42. Editorial, New York *Times,* Sept. 3, 1951.
43. New York *Times,* Nov. 4, 1951, pg. 62, Col. 1.
44. N. Y. *Times,* Jan. 16, 1952, pg. 7, col. 2.
45. All seven sections are from the 1958 Edition of the *U. S. Code.*
46. Author's italics.
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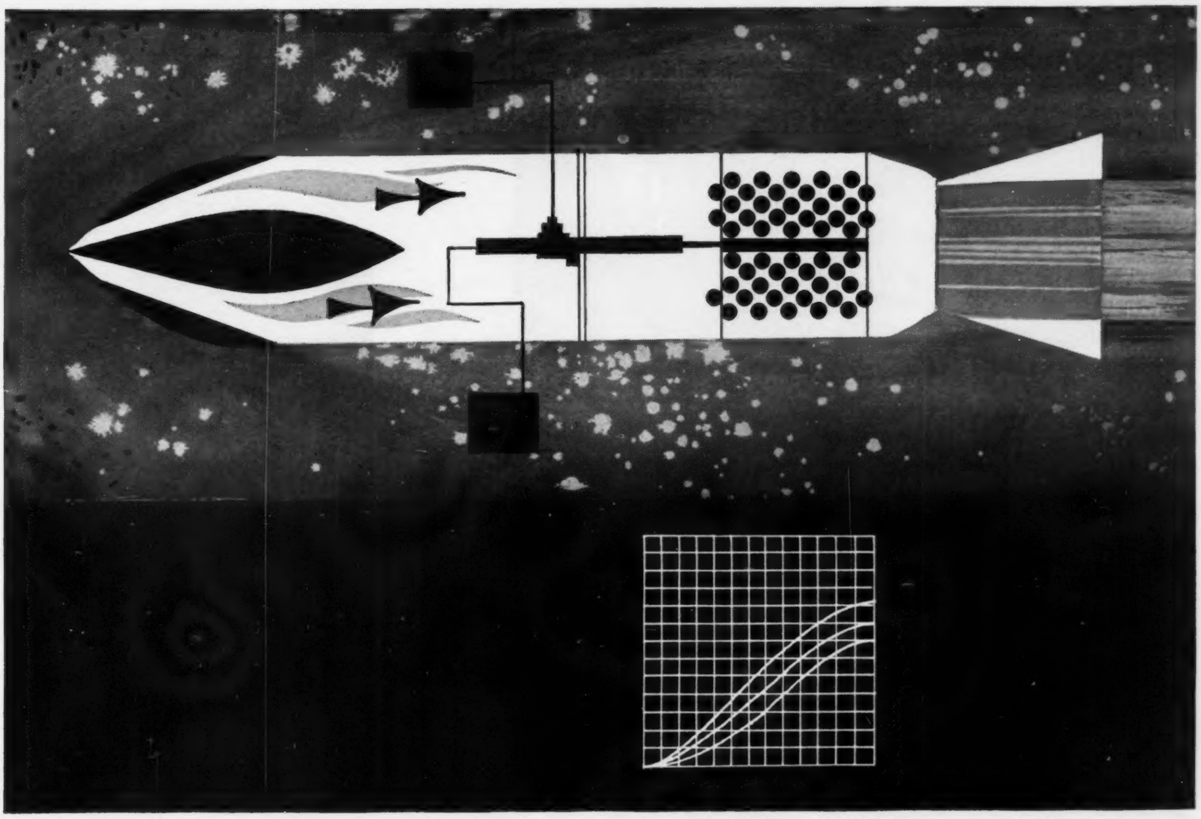

• One in a series of messages on how to plan your career

Hopping or marching— two paths to a career

A career is sometimes defined as a succession of jobs, whether with a succession of employers, or within a single company.

A man is commonly said to be "hopping" when he progresses by switching from one employer to another.

The man who sticks with a single employer can be said to progress by "marching."

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LIQUID HYDROGEN—THE ULTIMATE FUEL

by Robert L. Kaplan, EE '64

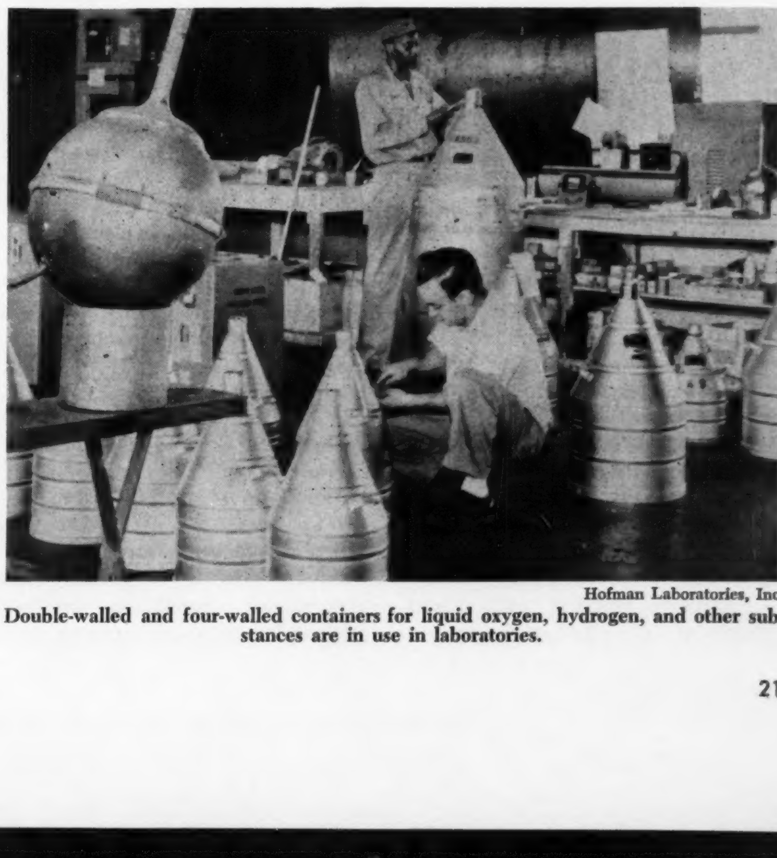
The goal of rocket propellant chemists recently has been to contain as much hydrogen as possible in rocket fuels. Scientists have compounded hydrogen with lithium and boron, the next most efficient fuel elements, as solids and as thick liquid slurries. Better than a compound, however, is pure hydrogen.

As a fuel, hydrogen develops more thrust per pound than kerosene, the standard ingredient of liquid rocket engines today. When hydrogen combines with oxygen, its hot exhaust is mostly molecules of water (molecular weight eighteen) which are much lighter than carbon dioxide (molecular weight forty-four) in the exhaust of kerosene-oxygen engines. Since light molecules travel faster at a given temperature than heavier molecules, they carry more energy per pound. In rocket language, the hydrogen engine produces a "specific impulse" thirty per cent greater than kerosene-burning rivals.

The interest in liquid hydrogen stems mainly from its role as the "ultimate" chemical fuel. I say ultimate because more specific impulse is provided by burning hydrogen than any other fuel—no matter what the oxidizer is. The reason is obvious by elementary chemistry. Hydrogen, the lightest element, has but one electron available for chemical reaction. Since its atomic weight is one, hydrogen has one reaction electron available for each unit of atomic weight. However when heavier atoms are used as fuel, there is no proportionate increase in the number of reaction electrons. Why then didn't we build liquid hydrogen rockets long ago? Why don't we have them today? The answer to the latter question is that we will have them very soon. The former question is far more involved.

Basically, the answer has been that because of its very low boiling point (–423° Farenheit), hydrogen was extremely difficult to keep in its liquid form and had proved too tricky for use in major rocketry. About twenty per cent of liquid hydrogen boils away in a single day, even though it may be kept in high-vacuum insulated refrigerated dewares holding 500 gallons. The refrigeration is necessary because the hydrogen molecule exists in two different forms: one in which the two protons are spinning in the same direction (orthohydrogen) and one in which the two protons are spinning in opposite directions (parahydrogen). Gaseous hydrogen at room temperature contains about twenty-five per cent parahydrogen and seventy-five per cent orthohydrogen. When cooled to the boiling point of –423° Farenheit, this mixture becomes highly unstable. At this temperature the two forms do not reach equilibrium until ninety-nine and eight tenths per cent of the molecules shift from the ortho to the para form. The transformation from ortho to para requires a long time under ordinary conditions. It takes about a month for twenty-five per cent para to convert itself to ninety per cent. The conversion releases heat, because parahydrogen is in a lower energy state than ortho. (It is more stable.) This is similar to a two-engine airplane where each engine spins in an opposite direction to equalize the torque and make the plane more stable in flight.

Because of this continual release of heat as ortho changed to para, liquid hydrogen produced by older methods needed to be continually refrigerated. Even so, it was continually boiling off. Scientists searched for catalysts that would speed up the conversion, so that the product would be more stable. The first major break came in 1953, when workers at the Los Alamos Scientific Laboratory succeeded in modifying a small hydrogen liquifier for the regular production of eighty-five per cent para liquid at the rate of twenty-five liters (three pounds) per hour. A short time later, the hydrogen liquifier at Boulder was modified to produce 240 liters per hour of ninety to ninety-five per cent parahydrogen. Under Atomic Energy commission sponsorship, the Cryogenic Engineering Laboratory at

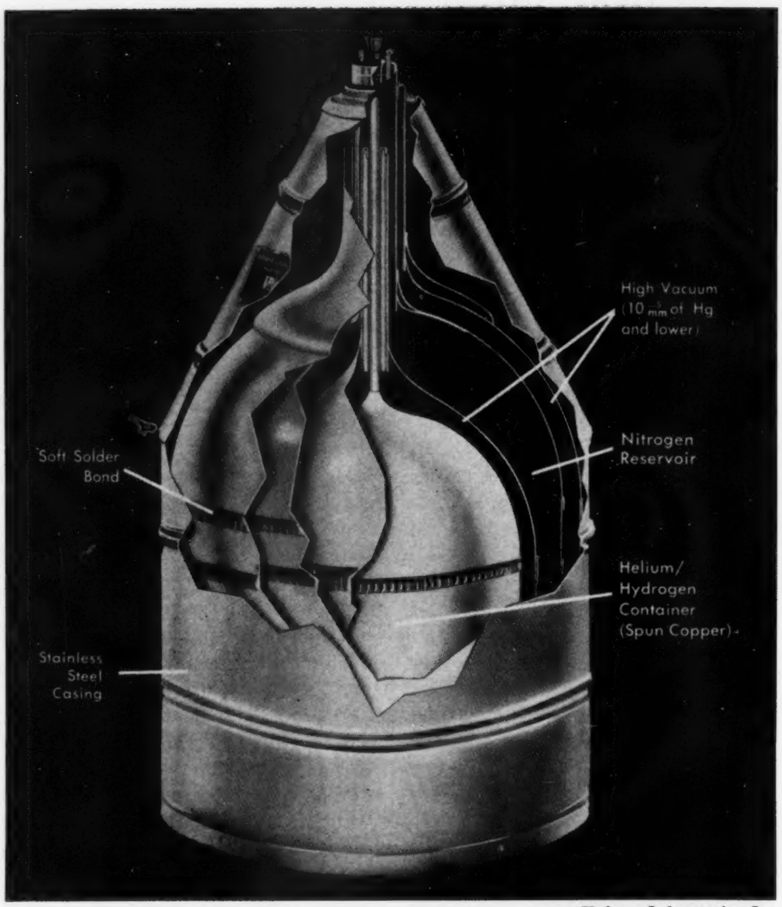


Hofman Laboratories, Inc.

Double-walled and four-walled containers for liquid oxygen, hydrogen, and other substances are in use in laboratories.

Boulder began a catalysts research program directed by D. H. Weitzel. The most effective catalyst, they discovered, is hydrous ferric oxide. To make hydrogen stable as a liquid, scientists would treat it with hydrous ferric oxide, an iron rust that has further combined chemically with water, by allowing the liquid hydrogen to run over a bed of these particles. The catalyst would flip over some of the atoms so spins of each hydrogen pair are in opposite directions. The homogeneous parahydrogen then releases no appreciable heat and can be stored for a month with only a small loss. The catalyst's high conversion efficiency makes it possible to design ortho-para converters about 1/40 the size of those used in the early work and to hold to manageable size the converters for the very large scale new plants. If as much as 10,000 pounds a day are purchased from a large plant, government officials say the price will average only about 50 cents a pound.

The cold liquid, once thought to be extremely hazardous, now is considered only a moderate danger. Precautions are necessary, but liquid hydrogen is less flammable than propane, commonly stored in tanks in rual homes. Through the years of dealing with hydrogen, safety precautions have been devised for the design of production plants. All equipment containing liquid hydrogen, except for the compressor building which is six stories high and a quarter mile long, is located outside where leaking lightweight hydrogen will dissipate rapidly upward. All equipment containing hydrogen gas or liquid is kept at a pressure above atmospheric to avoid contamination with oxidants. A rather extensive alarm system tells when pressures drop below safe limits and shuts down the compressors if the conditions are not corrected. Under normal conditions, little hydrogen gas escapes into the atmosphere. Leaks in a liquid hydrogen system can usually be detected by the cloud of ice crystals and water vapor around it. If the leaking hydrogen is burning, it will be harder to detect because burning hydrogen is invisible in daylight.



Hofman Laboratories, Inc.

Hydrogen and other liquified gases are contained in specially designed containers.

Engineers working with liquid hydrogen agree that spills are not dangerous so long as there is no source of ignition. A few gallons spilled will evaporate immediately. When hundreds of gallons are spilled, the ground freezes, the air liquifies, and a cloud of ice crystals and water vapor forms. Although warm hydrogen is much lighter than air, a large mass of very cold gas may have about the same density as air and lie along the ground until it picks up heat. However, the adjacent air has less than one tenth per cent hydrogen. Hydrogen makes an explosive mixture with air when its concentration is anywhere from four to seventy-four per cent. Thus any explosion and fire will be confined to the volume of the cloud. A spill that is ignited immediately will burn smoothly in air without exploding. The fire creates an extremely strong updraft, so that damage is usually confined to material directly overhead. Thus test stands should be designed with no important equipment overhead. A constant alert is necessary, of course, against the danger from sparks, flames, and lightning.

Hydrogen, in the form of an odorless, colorless, frigid liquid—the lightest there is—has progressed in less than a decade from a laboratory curiosity to the product of a large-sized industry. Rocket fuel and research needs alone have created a multi-million dollar industry. For example, the Centaur rocket, fueled with liquid hydrogen and LOX (liquid oxygen) will be flight-tested within a year and is expected to become a "workhorse" of our space age. When it is realized that only nine years ago the largest installations produced less than fifteen pounds of liquid hydrogen and now the daily production is measured in tons, we can see what importance has been attached to this liquid and can predict with assurance the immense increase in production and consumption of liquid hydrogen—the "ultimate" fuel.

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ANTENNA SYSTEMS

by Lloyd Goldman, Arts '63

One of the most familiar objects of modern times is the antenna. Sprouting up like forests of metal on homes, automobiles, office buildings, and almost anything else that has room for them, antennas have achieved a place in our society that is unique compared to any other man-made article. Yet, even though it is so ordinary, the antenna is not often understood. Everyone seems to accept the existence of the antenna, but never to question how or why it "works." The average man replaces his indoor TV antenna with a rooftop model or turns his transistor radio in a different direction in order to get better reception, but he does not know why he does it. A closer look at antenna systems is intended in this article.

There are two types of antennas: these are the transmitting antenna and the receiving antenna. Both of these types usually serve a twofold purpose. The major function of a transmitting antenna is the efficient radiation of the power furnished by the transmitter. The second function may be to direct the power into directions where it is wanted and to prevent transmission in directions where it is not wanted. In the same manner, the chief function of a receiving antenna is the capture of power from a passing radio wave. A second function may be to favor radio waves coming from a particular direction, while discriminating against waves coming from another direction. In both systems the directivity function also serves to increase power radiated in or received from a given direction. The directivity function has a bearing on the engineering of an antenna, as only a simple structure may be required for a non-directional antenna, while a more complicated structure may be required for a directional system.

Basically, an antenna is an electric circuit of a special kind. In an ordinary circuit, the dimensions of the circuit components, that is to say, coils, condensers and connections, usually are small compared to the wavelength that corresponds to the frequency in use. In this case, most of the electromagnetic energy stays in the circuit itself and is either used up in performing useful work or converted into heat. But when the dimensions of wiring or of components become appreciable compared with this wavelength, some of the energy escapes by radiation in the form of electromagnetic waves. A transmitting antenna is a circuit intentionally designed so that the major portion of the energy is radiated.

In the ordinary circuit inductance is usually concentrated in a coil, capacitance is in a condenser, and resistance is, for the most part, in resistors although some resistance may be distributed around the circuit wiring and coil conductors. Such a circuit is said to have "lumped constants." In an antenna, however, the inductance, capacitance, and resistance are distributed along a conductor. This type of circuit is said to have "distributed constants." Usually, the antenna is a straight section of conductor or a combination of such conductors (pipes, rods, etc.). Frequently, the conductor is a wire. The term "wire," therefore, will generally be used in this article to mean any type of conductor having a cross section that is small compared to its length. In this article, although most of the emphasis will appear to be on transmitting antennas, the same rules apply to receiving antennas in general. A good transmitting antenna for any frequency will be a good receiving antenna for the same frequency and for the same reasons.

Since the chief function of the antenna is to transmit the maximum power from a given transmitter, the antenna must be a tuned circuit in *resonance* with the transmitter. When the tuned circuit is in resonance with the transmitter, the inductive reactance (X_L) and capacitive reactance (X_C) cancel each other out, leaving only the small resistance of the wire (R). Since the current (I) flowing in the tuned circuit is equal to the voltage (E) divided by the impedance (Z), and since the impedance of this resonant circuit is equal to only the small resistance (R), it is seen that at resonance the current is at its maximum value. Thus, since the power is equal to the square of the current times the resistance ($P = I^2 \times R$), at resonance, we have the maximum power delivered to the antenna which represents the tuned circuit.

The shortest length of wire that will resonate to a given frequency is one just long enough so that an electric charge may travel from one end of the wire to the other and back again in the time of one radio frequency cycle. Now, the speed at which such a charge travels is

approximately equal to the velocity of light or about 300,000,000 meters per second. The distance it will cover in one cycle will be equal to this velocity divided by the frequency in cycles per second, or, if lambda (λ) is the wavelength in meters, $\lambda = \frac{300{,}000{,}000}{F}$. Since the charge traverses the wire twice (back and forth) the length of wire needed to allow the charge to travel a distance λ in one cycle is $\lambda/2$, or one-half wavelength. There fore, the shortest resonant wire will be a half wavelength long. The reason for this length can be shown quite simply. If we imagine a trough barred at each end and we start a ball rolling along the trough, the ball, if elastic, will bounce off of the far barrier, return to the near barrier, bounce again and continue in this manner until all of its original energy is dissipated. If, however, whenever it returns to the near barrier it is given a new push as it starts away, the motion back and forth may be kept up indefinitely. The pushes or impulses must be properly timed or in other words, the rate or frequency of the impulses must be adjusted to the length of the ball's travel and the rate of travel. On the other hand, if the timing of the impulses and the speed of the ball are fixed, the length of the trough must be adjusted. In the case of the antenna, the speed of the electric charge is essentially constant, so that we may adjust the frequency to a given length of wire, or adjust the length of wire to a given frequency. Usually, the latter action is the one that is used. A more useful formula for determining the length of a half wave antenna is $L = \frac{492}{f\ (\text{Mc.})}$, where L is the length in feet of a half wavelength for a frequency f given in megacycles (millions of cycles) when the wave travels with the velocity of light.

The "electrical length" of a linear circuit such as an antenna is not necessarily the same as its "physical length." The electrical length of the antenna is determined by the time taken for the completion of a specified phenomenon. For example, if we should have two different conducting mediums in which the electric charge travels at different speeds, the problem of obtaining resonance in each wire means the adjustment of the lengths of the wires so that the electric charge will make a round-trip in the time of one r. f. cycle. It will be found that the physical length of the circuit with the lower velocity of propagation is shorter than the circuit with the higher velocity of propagation. Their electrical lengths are identical, however, each being a half-wavelength.

When the antenna is fed by the transmitter, it is found that at certain points along the antenna, separated by distances corresponding to half the wavelength of the output of the transmitter, the current will always be a minimum. These points are called "current nodes." At points halfway between the nodes, we find that the current is always at some maximum value, which is known as a "current antinode" or "loop." it is also found that at the point of a current node, there will be a voltage loop, and at the point of a current loop, there will be a voltage node. The distribution of current and of voltage between their respective nodes and loops along an antenna is sinusoidal in form. (see figure 1)

The reason for this distribution is the presence of "standing" waves. Standing waves are formed in the following way: If we should throw a stone into a still pond of water a short distance from shore, a water wave is formed (figure 2). The wave radiates from the center of the disturbance to the shore. The solid line in fig. 2-A represents the advancing, or incident wave, which strikes the shore and is reflected. The reflected wave, shown by the

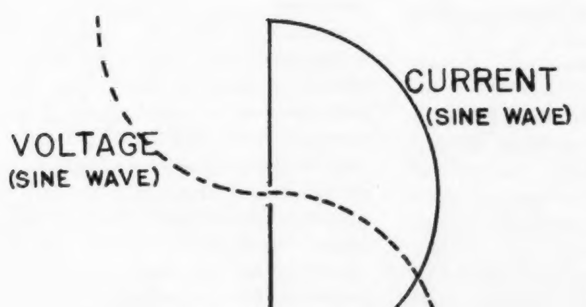


Figure 1. The voltage and current distribution in an elevated half-wave antenna.

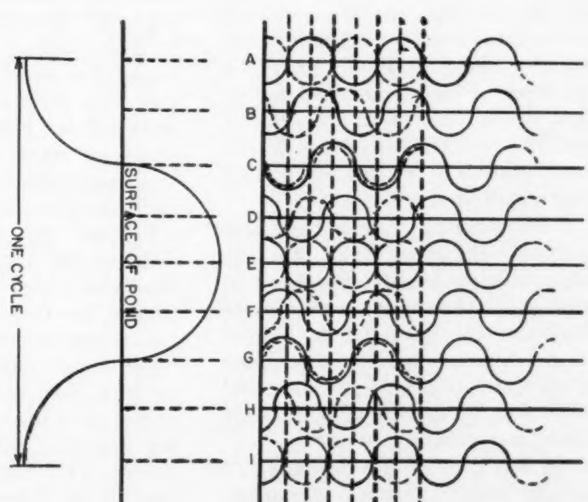


Figure 2. Standing waves in water. Each step is one-eighth of a cycle later than the step before. J shows the resultant waves of A to I.

dotted line is nothing more than a continuation of the original wave except that at its point of reflection it has been reversed. Therefore, the reflected wave is the mirror-image of the original wave, as it would have been had it not been reflected by the shore. At all points, the reflected wave is 180° out of phase with the incident wave, which results in the cancelation and neutralization of any pressure exerted on the water particles by the incident wave. The resultant wave is indicated by the dot and dash line.

In fig. 2-B, an eighth of a cycle later, the incident and reflected waves are in phase at certain points and out of phase at other points. Where the waves are in phase, they reinforce one another, with a greater resultant pressure exerted on the water particles at that point. Where they are out of phase, they tend to neutralize one another, and at points 180° out of phase, complete neutralization takes place.

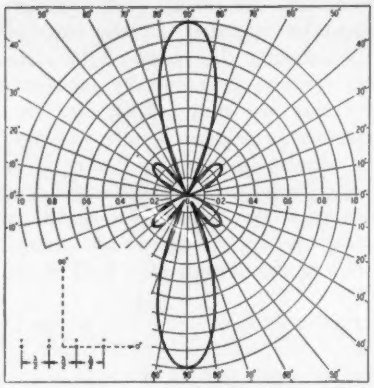
Figures 2-C to I are successive eighth-cycles apart. By combining the resultant waves in figure 2-J, it is noticed that a node always occurs at points 1, 3, 5, and 7 and that all of these points are a half wavelength from the nearest adjacent nodes. Also, the antinodes are a half wavelength apart and occur mid-way between the nodes (points 2, 4, 6, and the shore).

The combined action, therefore, of the incident and the reflected wave produces a resultant wave that appears to stand still. The particles of water are moving up and down (except at the nodes), but the crests of the wave do not move forward or backward. This is a standing wave.

The particles of water have zero vertical velocity at the point where the water waves strike the shore. At this point, however, the pressure becomes the greatest. It follows that wherever there is a pressure loop, there is a velocity node and wherever there is a velocity loop, there is a pressure node.

In the case of the antenna, we obtain standing waves of current that correspond to velocity and of voltage that correspond to pressure.

Figure 1 shows a common type of antenna, the doublet or dipole antenna. This antenna is simply an elevated wire with the transmitted



A.R.R.L. Antenna Book

Figure 3. Free-space directive diagram of a four-element broadside array using parallel elements. This is also the horizontal directive pattern at low wave angles for a vertically-polarized array.

power applied at the center. Obviously, there can be no flow of electrons at the ends of the antenna, so that the standing current wave must end in nodes. Since there is practically no current flow at the ends of the antenna, the electrons tend to pile up at these points and the voltage (electrical potential) becomes a maximum.

The radiation from a practical antenna never has the same intensity in all directions. The intensity may range from a zero value in some directions to a value which is greater than that which one would expect from an antenna that radiates equally well in all directions. An antenna that *does* radiate in all directions does not exist. It is convenient, however, to assume that such an antenna is in existence in order to use it as a standard for measuring the properties of actual antenna systems. This hypothetical antenna is called an "isotropic radiator."

Graphs are commonly drawn showing the actual or relative intensity at a fixed distance as a function of the direction from the antenna system. These graphs are called "radiation patterns." Such patterns may not really be represented in a plane drawing as they are, naturally, three-dimensional in nature. The "solid" radiation pattern of an antenna in free space would be found by the measuring the field strength at every point on the surface of an imaginary sphere which has the antenna for a center. The solid pattern of an isotropic radiator would be a sphere since the field strength is identical in all directions.

Without going into detail about the construction or design of various antenna systems, a plane directive diagram is shown in figure three. The points on the pattern where the radiation is zero are known as "nulls" and the curved section from one null to the next on the diagram, or the corresponding section on the solid pattern, is called a "lobe" or "ear." It is the directive quality of various antenna systems that causes radio stations to "fade" when a portable radio is rotated. This directive property is especially useful in short wave communication where "Beam" antennas are used to transmit the maximum amount of power in a particular direction.

The purpose of the transmitting antenna is to radiate the radio wave and, therefore, the antenna is treated as a resonant circuit tuned to the frequency of the radio wave in order to insure maximum power transfer. In the same way, the receiving antenna should be a resonant circuit tuned to the frequency of the radio wave in order to receive maximum power transfer from the radio wave. In the ordinary broadcast band (535 to 1605 kilocycles), the construction of such an antenna is not, however, very practical. For example, a half-wavelength of the radio wave that is broadcast by radio station WTKO (1470 kc.) is equal to approximately 112 yards. Generally, the power of the broadcast transmitter is large enough so that most broadcast receivers will not use a resonant antenna, but rather a self-contained loop antenna. In unusual cases where the receiver is a distance away from the transmitter, an elevated wire about 100 feet long will generally suffice. In the case of the FM broadcast band (88 to 108 megacycles), the regular television band (54 to 216 mc.), and the ultra-high-frequency television band (470 to 890 megacycles), the resonant antenna is practical. In the regular television band, for example, half-wavelengths range from 0.7 to 2.75 meters. It is fairly easy to construct and to erect antennas of these lengths.

There are two major types of antennas in common use: the "Hertz"

antenna and the "Marconi" antenna. The Hertz antenna is probably the most common. It is the elevated-wire type of antenna and was invented by Heinrich Hertz. The Marconi antenna, invented by Guglielmo Marconi, uses the ground as a sort of electrical mirror. One end of the transmitter is connected to the antenna wire and the other end to the ground. By using the ground as a "mirror," a Marconi antenna may be cut to only a quarter of a wavelength which makes it a more desirable antenna at the longer wavelengths, especially if a vertical antenna is constructed (figure 5).

Since the base of a Marconi antenna is at ground potential, a voltage node must occur at that point. Because of this, only odd multiples of the quarter wavelength may be used in constructing a Marconi antenna. The Hertz antenna, on the other hand, may be constructed and designed at any integral multiple of the half-wavelength.

To conclude this article, it is felt that a brief look at television receiving and transmitting antennas would be desirable since we are probably more familiar with TV antennas than with any other. Antennas that are used for broadcasting television programs must fulfill certain requirements. They must radiate, in the United States, horizontally polarized signals. (In England, and in certain other countries, vertical polarization is the standard.) The antenna is usually required to be "omnidirectional," that is, it should radiate uniformly in all directions in the horizontal plane. Finally, the antenna should be impedance matched with the transmission line that is feeding it over the full range of the channel, a six megacycle bandwidth. If the last requirement is not satisfied, the portion of the signal which is reflected back along the transmission line because of the mismatch at the antenna will be reflected again at the transmission terminals and make a second trip down the transmission line. The time delay, on an extremely long transmission line, between this signal and the original signal may cause a second image or "ghost" to appear on the receiver.

The same general considerations apply to the selection of an antenna type for television as apply to any other type of reception. It is not as essential that the impedance of the antenna and the transmission line be matched as in the case of the transmitting antenna, because there will be no reflections along the transmission line as long as the receiver input circuit is properly matched to the line. Increased directivity is desirable to improve the signal strength in fringe areas or, in areas very close to the transmitter, to eliminate reflected waves coming from different directions which may cause ghosts.

The television antenna which we see on most homes is usually no more than a dipole or folded dipole antenna, which is useful for single channel coverage. Multi-element "yagi" arays are also used to increase directivity.

For the most part, then, it is seen that antennas for all applications obey the same basic rules. From a simple wire in the attic to a complex structure of towers, girders, and reflectors, the antenna enables words and ideas to travel all over the world at the speed of light.

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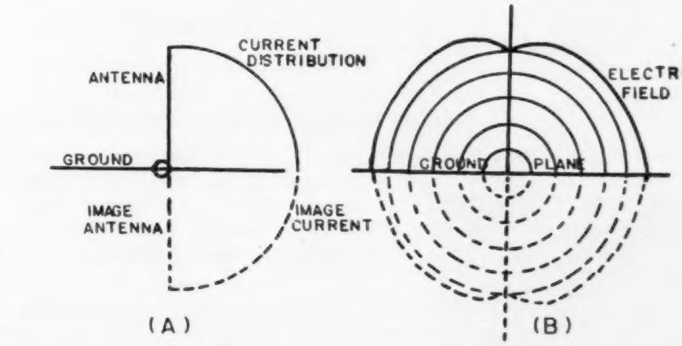


Figure 4. A quarter-wave vertical antenna at the surface of the earth. (a) antenna and its image, showing current distribution; (b) electrostatic field about the antenna, showing how the image antenna can be used to account for the effect of the ground.

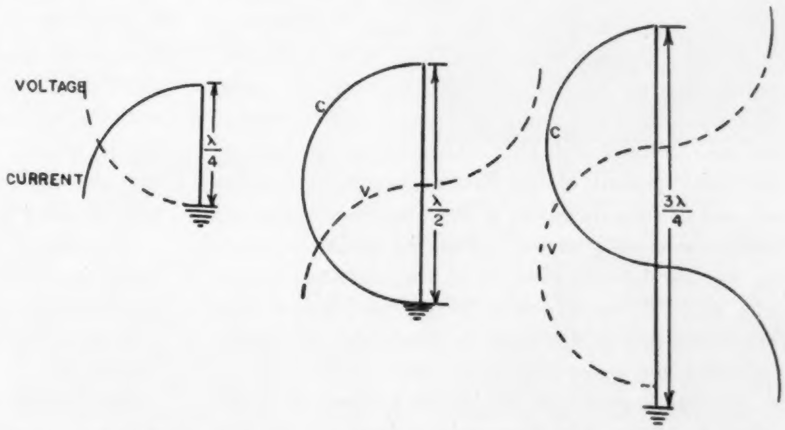


Figure 5. Marconi-type antennas of different lengths. Note that in the 1/4 wavelength antenna the node is at the ground. In the 1/2 and 3/4 wavelength antennas, the node is not at the ground.

CORNELL SOCIETY OF ENGINEERS

107 EAST 48TH STREET 1961–62 NEW YORK 17, N. Y.

"The objects of this Society are to promote the welfare of the College of Engineering of Cornell University, and to foster a closer relationship, than would otherwise be the case, between the College and its alumni for the benefit of that institution."

THE PRESIDENT'S LETTER—

We held our second dinner meeting of the Society on Thursday, November 30 at the Engineers' Club in New York. This was during the week of the A.S.M.E. annual meeting, so we had the opportunity of seeing a number of out-of-towners who were attending these sessions. Included was Harry Loberg, the Director of the Sibley School of Mechanical Engineering, who was one of nine members of the Cornell Engineering faculty presenting papers before the A.S.M.E. meeting. We also had the pleasure of congratulating Ernest Selig, M.E. '57 on receiving the Pi Tau Sigma award for outstanding achievement in mechanical engineering within ten years after graduation. Ernest received his Masters degree from the Illinois Institute of Technology in 1960 and is now working there on his Doctorate.

Our speaker for the evening was William Littlewood, M.E. '20 – Vice President of the American Airlines, Trustee of the University and a former President of the Society. He gave an extremely interesting and informative picture of the problems and promises in the supersonic field and in the short range vertical flights. His talk gave rise to a great many questions so that we kept him occupied over two hours in dealing with this subject.

Our next meeting is scheduled for January 31, 1962 which is during the A.I.E.E. winter meeting. I hope all of you Electrical Engineers will put this date on your calendar and plan to be with us if you are in New York.

Our Membership Chairman tells me that there are still a substantial number who have not yet sent in their dues. If you are one of these, please do so, as we need your support.

PAUL O. GUNSALUS

ALUMNI ENGINEERS

Edited by
Stanley Schlozman, ME '65

D. Brainerd Holmes, BEE '43, a veteran of the missile industry, will direct President Kennedy's stepped-up drive to send a man to the moon by 1970. Mr. Holmes is currently project manager for development of the ballistic missile early warning system (BMEWS) by RCA Defense Electronic Products at Moorestown, N. J.

Mr. Holmes will head America's manned space flight programs, including Project Apollo—the mission to place a man on the moon.

Eugene F. Murphy, ME '35, has been awarded a Citation for Meritorious Service by the President's Committee on Employment of the Physically Handicapped. The nomination for this award came from the New York State Governor's Committee on "Employ the Physically Handicapped" in recognition of Mr. Murphy's contributions to the employability of disabled people.

Mr. Murphy, himself a victim of polio at age eleven, has made a remarkable adjustment to his disability. He has dedicated the past 15 years to the development and improvement of artificial limbs, braces, hearing aids and guidance devices, and reading machines for the blind.

Harvey N. Roehl, ME '49, is the author of the first history of the mechanical piano in America, *Player Piano Treasury*. This book, published by the Vestal Press, tells the story of this once vast industry. Mr. Roehl is presently a member of the administrative staff of Broome Technical Community College in Binghamton.

Robert A. Skinner, CE '17, has been appointed to the position of General Manager and Chief Engineer of the Metropolitan Water District of Southern California. Mr. Skinner has been in the service of the Metropolitan Water District since 1933. In 1941 he was made Chief Operation and Maintenance Engineer and in 1950 he became Assistant General Manager and Chief Engineer.

Stanley Noss, BME, '44, has been appointed head of the marine system operations department at Sperry Gyroscope. In his new position he is responsible for operational aspects of a navigation subsystem for Polaris submarines, including integration, systems design, digital techniques, and field operations. After joining Sperry as a project engineer in 1951, Mr. Noss was promoted to assistant design section head in 1954, and to design section head in 1956.

Juan J. Martinez, ME '27, is the first person residing outside the United States to be elected to the Cornell Board of Trustees; he will serve a five-year term.

Mr. Martinez is a prominent consulting engineer in Mexico City, and for the past four years he has been a board member of the Industrial Productivity Center of Mexico—a joint endeavor in which representatives of private industry, labor unions, the Mexican government and the International Cooperation Administration in Washington participate. He was associated with the Mexican Light and Power Company from 1927 to September of last year and was executive vice president during the last three years. He is also a member of other organizations in the field of international engineering and economics.

He was one of the youngest men ever to receive a Cornell degree, graduating in 1927 at the age of 19.

Richard A. Kenyon, MS '56, has recently completed a book entitled, *Principles of Fluid Mechanics*, published by the Ronald Press. Mr. Kenyon taught in the Mechanical Engineering school from 1954–56 and during three summers served as an engineer in General Electric's gas turbine division. He has done much research in turbomachine flutter. Mr. Kenyon is now a member of the faculty of Clarkson College of Technology.

L. R. Anderson, BS in EE '47, MS in Eng '48, will become manager of the Northern Sales District for GE's lamp sales department beginning in 1962. He is currently a commercial and industrial sales specialist for the Wisconsin Sales District.

A World War II veteran, Anderson was graduated with honors from Cornell University with B.S. and M.S. degrees in Electrical Engineering. He was a member of social and honorary fraternities including Eta Kappa Nu, Tau Beta Phi, Sigma Xi and Phi Kappa Phi, and was editor of the *Cornell Engineer.*

He served in General Electric's lamp department during the summer of 1947 and returned following graduation in September, 1948 in lamp application engineering at Nela Park, Cleveland, Ohio. In 1951, he moved to New York as a lamp engineer in the New York Sales District.

L. R. Anderson

Anderson later returned to Nela Park in Cleveland as a commercial and industrial lamp sales specialist. Then in 1959 he moved to Milwaukee in his present position as commercial and industrial sales specialist for the Wisconsin Sales District.

COLLEGE NEWS

Edited by Steve Whitman, EE '64

GILMOUR RESEARCH CONTINUED BY GRADUATE STUDENTS

As one phase of the extensive program of microwave research conducted by staff and students of the School of Electrical Engineering for the Rome Air Development Center, Dr. Alexander S. Gilmour, Jr., now assistant professor, began in 1959 a detailed study of electron beam characteristics which became the basis for his doctoral thesis.

His report, one of the most complete surveys of this highly specialized division of research, yielded much original information as to the d. c. and radio frequency current and velocity distributions of electron beams similar to those used in medium power klystrons and traveling wave tubes.

At the present time, other graduate students are continuing, under his direction, the investigation begun by Dr. Gilmour, and delving deeper into such questions as why non-laminarities occur in the beam, an effect that becomes important at the high powers (up to 50 million watts) used in apparatus such as the above mentioned klystrons and traveling wave tubes. Other phenomena they hope to clarify are included in a further analysis of the r. f. current and relative phases of different parts of the beam to one another.

The bulk of the study is carried on in an electron beam analyzer that was constructed at Cornell and has special facilities for examining beams. At the end of the analyzer where the electron beam is collected, there is a movable molybdenum plate containing a .010 inch aperture. This opening can be moved to any position in the path of the electron beam to sample the d. c. and r. f. current and velocity at that point. The results of the measurements are displayed on an x-y recorder.

It is expected that this study will lead to a better understanding of linear beam devices, which will eventually make possible the construction of tubes with greater efficiency, bandwidth, and power capacities than are presently feasible.

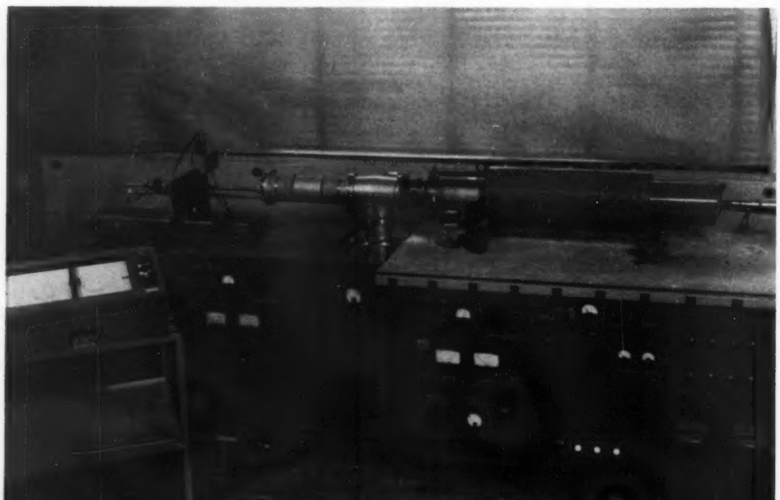


Fig. 1. Electron beam analyzer.

CAL'S T-33 PLAYS ROLE IN RECORD FLIGHT

When the X-15 set its new altitude record two months ago with Major Bob White at the controls it was called upon to make its re-entry maneuver for the first time. It was not, however, the first time that Major White had executed that maneuver in flight.

In addition to extensive ground-base simulations, all six X-15 pilots, including Major White, have flown re-entries in a flying simulator—a T-33 airplane with a variable stability system developed by Cornell Aeronautical Laboratory. The six pilots referred to are two from the Air Force, one from the Navy and three from the National Aeronautics and Space Administration.

Sponsors for the simulation project were the Flight Control Laboratory, and the X-15 Project Office of the Aeronautical Systems Division, Air Force Systems Command.

The plane used to simulate the X-15 looks almost like any other T-33 jet trainer. The similarity, however, is only external, for this T-33 is outfitted with a highly specialized flight control system which requires more than 600 transistors in the nose.

The variable stability T-33 is used for generalized research studies of flying quality requirements and criteria and for investigations of piloting problems of advanced aircraft. It is the only airplane which has simulated the X-15 re-entry in flight. On October 11 the X-15 attained an altitude of 215,000 feet, considered to be "outside the atmosphere."

While the pilots were flying the T-33, set up to have stability and

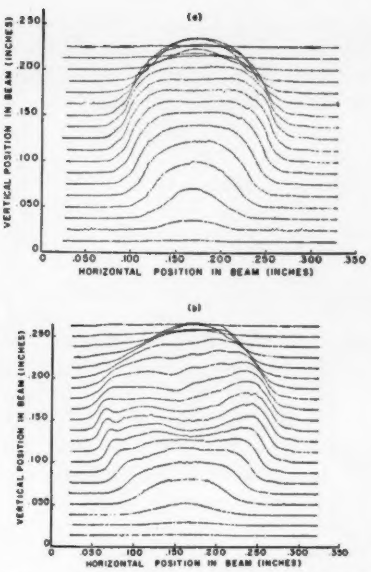


Fig. 2. Electron beam cross sections showing: 2a) ideal beam, 2b) beam disturbed by filament magnetic field.

control characteristics of the X-15, CAL test pilot Nello Infanti, in the rear cockpit, could assume command of the airplane at any time. His normal stick and rudder pedal controls remained mechanically attached to control surfaces at all times, and he was able to disengage the special control surface servos by any one of several methods.

After deactivating the special control system, Infanti was flying an essentially normal T-33. Takeoffs and landings are usually made by the safety pilot with the normal mechanical control system.

When flying on the variable stability system, control surfaces are positioned by hydraulically-operated servo units. Commands to each of the servos are the sums of the signals from the pilot's input through the cockpit controller and from airplane responses, such as angular velocities, angles of attack and sideslip—and their time rates of change.

The dynamic response of the basic T-33 airplane is altered by varying the amounts of these signals which are fed to the control surface servos. For example, roll damping can be modified by commanding aileron angle proportional to rolling velocity, and yaw damping can be modified by applying rudder angle proportional to yawing velocity.

When the CAL team took its unique T-33 to Edwards Air Force Base where the six X-15 pilots flew it 23 flights, the engineers knew that a major re-entry task was one of accurately controlling the load factor. In re-entry a period of weightlessness is followed by a pull-out in which several times the pull of gravity is experienced. The problem also involves the ability to adapt rapidly to a wide variation of stability and control characteristics.

During the X-15 re-entry the pilot trims the plane to a predetermined angle of attack to start the maneuver. When normal acceleration reaches a specified value, the pilot maintains it, reducing angle of attack by use of the normal aerodynamic controls which become effective in the atmosphere.

To duplicate the maneuver, the T-33 dives at maximum permissible speed before pulling up to a 45-degree angle. It is here that the airplane is pushed over to zero G, and a parabolic trajectory is established. At this point the safety pilot engages the special control system, transfers control of the airplane to the X-15 pilot in the front cockpit, and starts the programmer.

The X-15 pilot then takes control and rotates the airplane until the angle of attack displayed to him agrees with the specified re-entry angle of attack of the X-15. The T-33 load factor is increased during the rotation by the same amount as the X-15's—0.2G. Proper relationship between the displayed angle of attack and load factor is maintained by the programmer.

Reference to motion outside the cockpit is obscured from the evaluation pilot by a hood. However, by following the prescribed angle of attack and normal acceleration schedule for re-entry with wings level on the display instrument, he will automatically keep the T-33 on the specified speed-altitude relationship. A banked turn in the T-33 simulates the long pull-out in the latter part of the X-15 re-entry.

The X-15 pilot—flying the T-33—thinks he is performing a wings-level pull-out, while in reality he is going into a steep banked turn to maintain the proper G factor. This is done by slowly precessing the attitude gyro so the pilot is not aware of the motion. The instrument panel which he sees duplicates the essential instruments of the X-15, and information he reads is the same as the X-15 pilot will see during an actual re-entry.

CAL engineers believe significant advantages are obtained over earth-bound simulation programs.

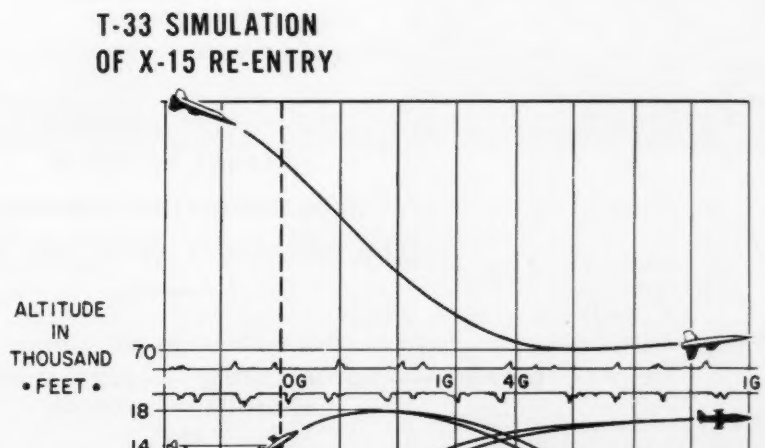


Fig. 3.

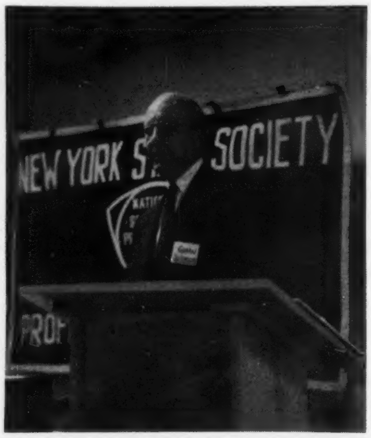
Chief of these, they explain, is that the pilot is realistically included in the problem. The environment and all the forces involved duplicate the problem. Thus, with minimum risks, the pilot can experience maneuvers, analyze the behavior pattern and devise techniques to cope with it before attempting the real thing.

NEW ENGINEERING GROUP MEETS ON CAMPUS

The Ithaca Area finally satisfied its need for a local chapter of the New York State Society of Professional Engineers in October 1961, with Professor True McLean opening the occasion with a brief review of the thinking, organizing and history that preceded the event. Several prior meetings were needed to generate interest, set up the by-laws for approval, and nominate a slate of candidates for office.

The candidates for office were unanimously elected as follows: Charles F. Green, pres; Thomas G. Miller, Vice Pres; Stanley W. Zimmerman, Treas; Charles R. Christian, Secy; William P. Kram and True McLean, directors. As a symbol of his office, Charles Green was presented with an enlarged gavel—resulting in laughs from everyone.

Mr. Paul Gunsalus of New York Telephone Company and President of the Cornell Society of Engineers, then reiterated the present

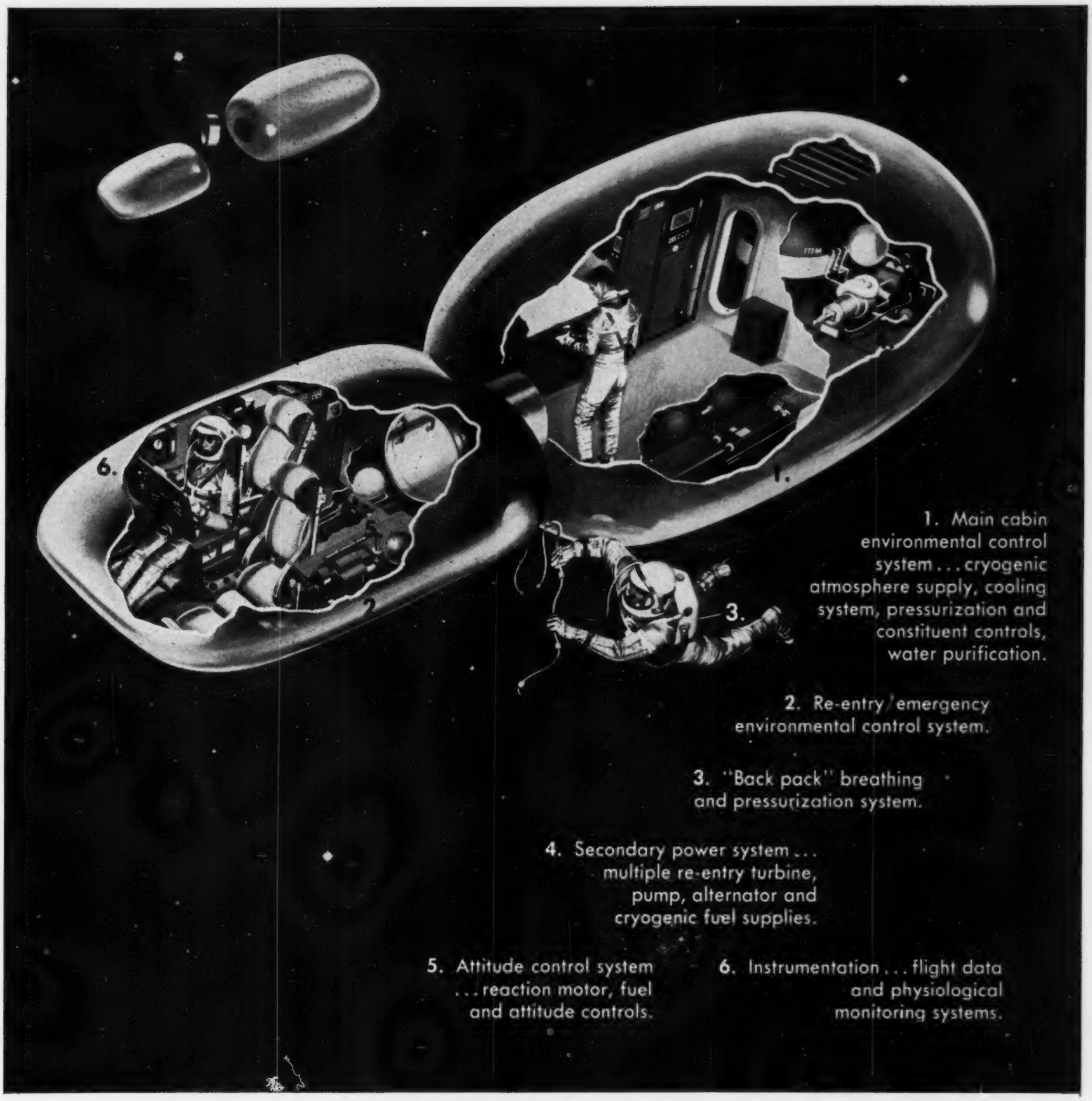


Charles F. Green, President-elect of Ithaca Area chapter of New York State Society of Professional Engineers.

opportunity for the Ithaca Chapter to expose the young crop of engineers in this area to professional competence and he also extended regrets from Charles Waldner of the Telephone Company who was most prominent in the early plans of chapter formation for Ithaca.

Leland Post, Chairman of the New York State Board of Examiners stated that in spite of the hard study involved, legal facets, ethics and conduct, and what not, one factor transcends all; "Members of Society accept an obligation of service to fellow man." At this time Mr. Post presented a license to Dale Corson, Dean of Engineering at Cornell University. Dean Corson responded that his experiences in engineering date back to 1938 but as he reviewed the history, he noted that "errors are made by Engineers" but knowledge continues to be gained. He felt better qualified to fulfill his obligations to all concerned and expressed his pleasure in receiving the certificate.

All speakers and visitors were thanked and a review of our State problems followed; for example, the union threat to our professional status. How the corrosive effect started in N. Y. City with the personnel Section, next with the Sanitation Dept., and so on to a possible national problem.



Manned space flight requires reliable and efficient thermal and atmospheric systems plus secondary power equipment. Complete, integrated systems (such as those pictured above) are under study at Garrett's AiResearch Manufacturing Divisions. Their design reflects 20 years of leadership in airborne and space systems, including NASA's Project Mercury life support system.

Other project areas at Garrett include: solar and nuclear power systems for space applications; electronic systems, including centralized flight data computer systems; and small gas turbines for both military and industrial use.

An orientation program lasting several months in diversified areas is available to every newly-graduated engineer to aid in his placement. It includes working on assignment with experienced engineers in laboratory, preliminary design and development projects.

For further information about a career with The Garrett Corporation, write to Mr. G. D. Bradley in Los Angeles.

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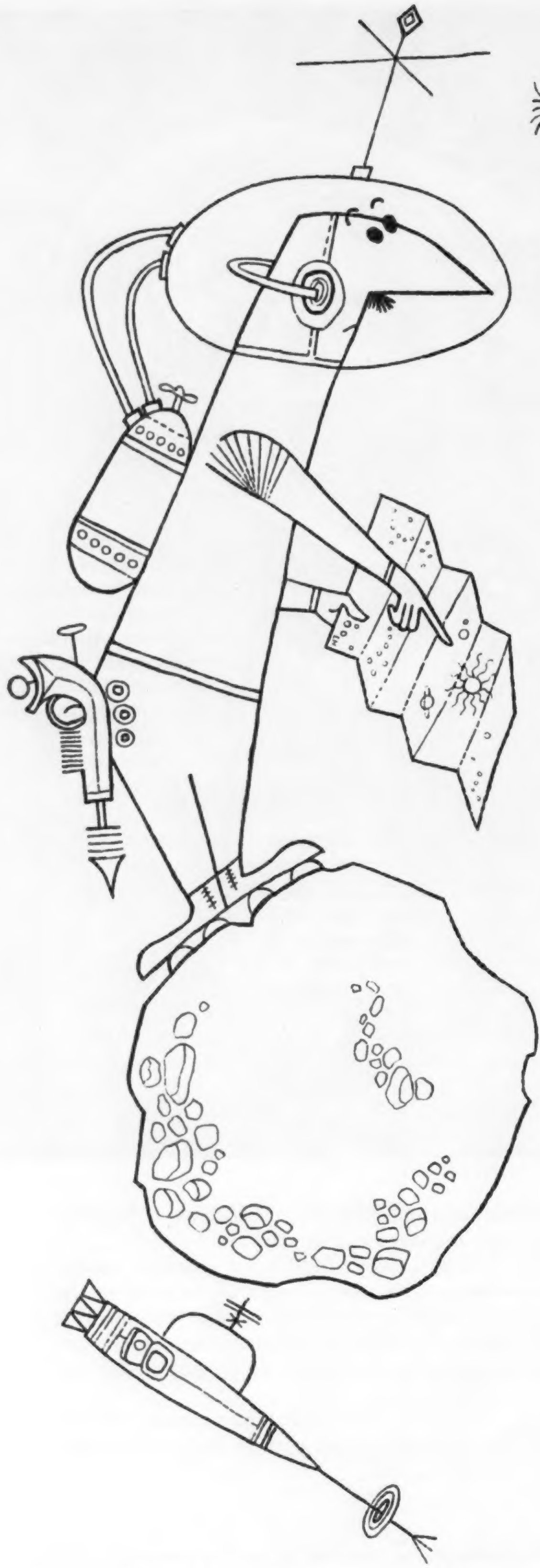

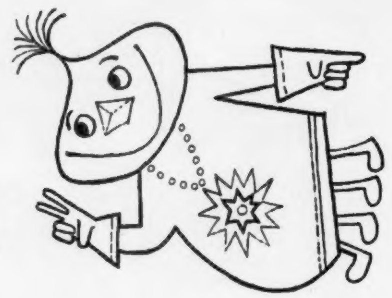

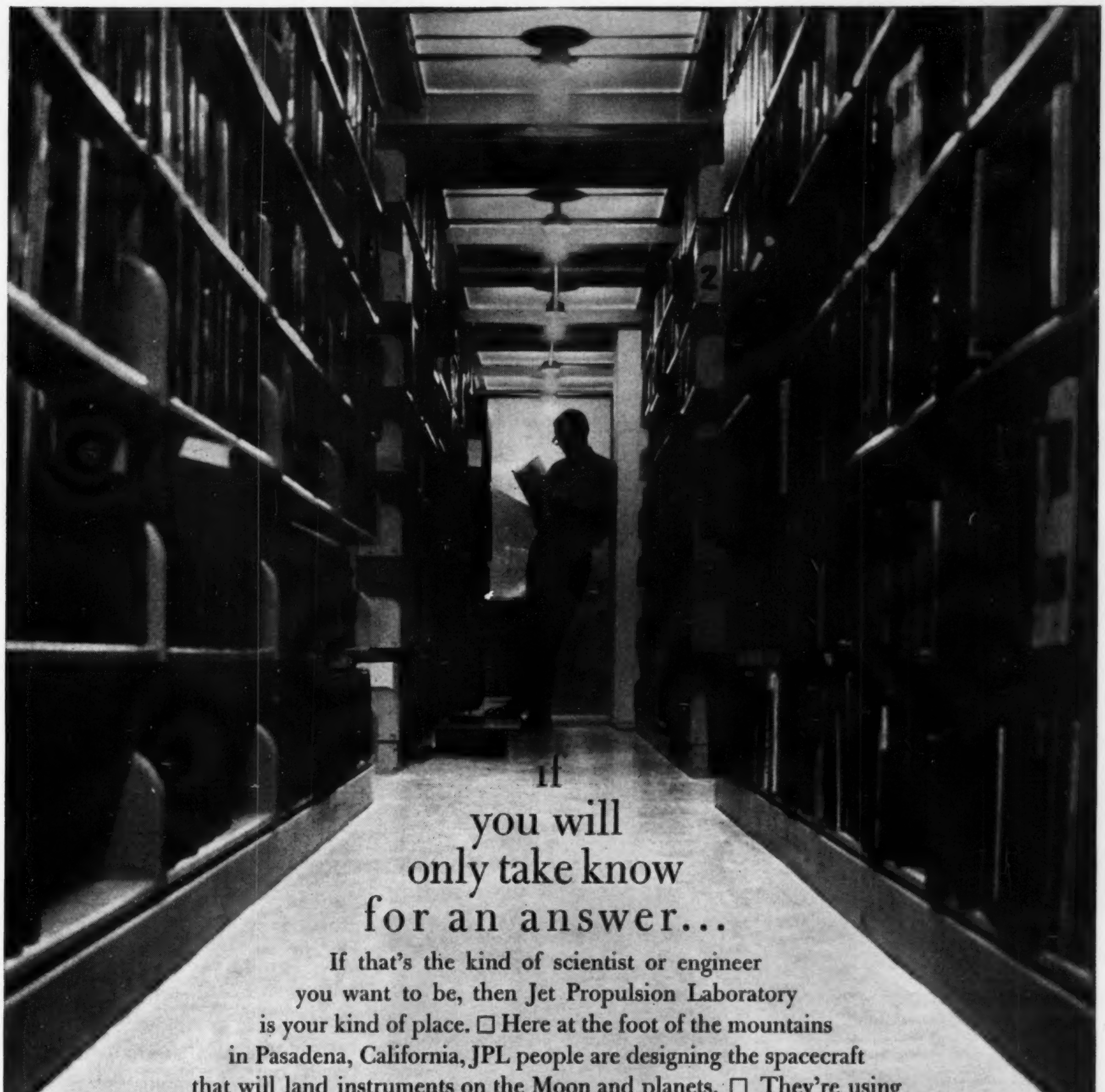
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TECHNIBRIEFS

Edited by Harry Green, Ch.E '63

AIRBORNE EDUCATION

Airborne TV classes began in six midwestern states this fall when upwards of 1,000,000 students began receiving televised instructions from an airplane circling lazily at 23,000 feet over central Indiana.

A DC-6 takes off from the Purdue University airport in Lafayette and, when it nears Montpelier, Ind., transmits a TV signal reaching into six Midwestern states within a 200-mile radius. An estimated 7,000,000 students are within the range of the TV signal. This milestone in education, undertaken by the Midwest Program on Airborne Television Instruction, links a potential 13,000 classrooms into a network offering instruction from the first grade level through collegiate courses. The historic flight and the ensuing programs which will run until late May, 1962, trace back to a system known as Stratovision® which was conceived and developed by Westinghouse engineers.

The high-flying TV station is manned by crews consisting of an engineer and two technicians who operate tape recorders aboard the plane and monitor picture and sound output for two channels which are telecast simultaneously.

It was in 1944 that Charles E. Nobles, an electronics and radar engineer, conceived the idea of sending a TV signal from an airplane. Mr. Nobles reasoned that as long as a ground-based TV station generally is limited to a broadcasting range of about 50 miles, an airborne system could extend reception to a far greater area.

He set out to prove his theory in a series of experiments running from 1945 through 1948. In June, 1948, before the days of the east-west coaxial cable, TV viewers as far away as Michigan watched the Republican National Convention in Philadelphia. A modified B-29 bomber, serving as a broadcasting studio in the sky, telecast the convention proceedings.

Later in 1948, the final baseball game of the Cleveland-Boston World Series was retelevised by the B-29. Reception of the telecasts was achieved in nine states.

Two years ago Stratovision took a new direction. Reuben Lee, a Westinghouse engineer in the electronics division, suggested linking Stratovision with educational television. The early test flights which demonstrated the feasibility of Stratovision were the forerunners of the present program.

The Ford Foundation and private industry are underwriting the test program. The Midwest Program on Airborne Television Instruction was formed to select a curriculum and recruit teachers for the experiment. Westinghouse was chosen to equip the airplanes and provide technical know-how and assistance.

The program is centered at Purdue University where MPATI makes its headquarters.

The Lionel Corporation has announced the successful development of a novel radiation measuring instrument which is expected to find wide use by home owners. It is capable of measuring radiation intensity following an atomic blast, not only inside the fallout shelter, but also by remote control, at various places inside the house and in the open at a distance from the house.

SUPERCONDUCTING MAGNET DEVELOPED BY WESTINGHOUSE

Scientists at the Westinghouse research laboratories have developed a super-strength, superconducting magnet. For its size, weight, and energy consumption it is by far the most powerful magnet ever built. Such a magnet has been vigorously sought in dozens of laboratories throughout the world. Until a year or two ago it was considered theoretically impossible to construct.

The size of a doughnut and only a pound in weight, the super magnet creates a magnetic field twice as strong as that from a conventional iron-core electromagnet as large as an automobile, weighing 40,000 pounds, and operated to saturation of the iron. Such a con-

ventional iron-core magnet needs its own power plant to continuously supply the 100,000 watts or more of power to run it. In contrast, the new super magnet runs from an ordinary automobile storage battery. The only power the battery continuously supplies is a few watts to overcome the small losses in the wires leading to the magnet.

The superconducting magnet produces a magnetic strength, or flux density, of 43,000 gauss (43,000 lines per square centimeter). It has no iron core because iron-core magnets begin to saturate at about 20,000 gauss, and can be driven to greater strengths only by the brute-force application of large amounts of power that force them beyond saturation. Their coils would melt almost instantly if they were not oil or water cooled.

The new magnet is the first of what are certain to be super-strength magnets of the future. Scientists agree that such magnets will revolutionize almost every aspect of man's use of electricity including the generation, distribution and use of electric power. "A superconducting magnet will allow us to perform some of the most crucial scientific experiments of our time," Dr. J. K. Hulm, associate director of the Westinghouse research laboratories, said. "It enhances considerably our chances for the direct, large-scale generation of electric power. It makes possible a whole new generation of powerful atom smashers. It increases the possibility of a magnetic 'bottle' in which the vast energy of the hydrogen bomb reaction can be harnessed for useful power. It makes more feasible some of the far-out methods proposed for long-distance travel in space."

The new magnet is wound from a wire which is a superconductor, materials which have the remarkable property of losing all electrical resistance at temperatures near absolute zero. Once started, supercurrents of electricity flow through superconductors forever without loss in strength. Until a few years ago superconductors were simply a laboratory curiosity. Scientists believed that strong magnets could not be made from them because the magnetism they create by their supercurrents destroys their superconductivity. Last year it was proven that certain superconductors retain their properties even in strong magnetic fields.

The superconducting magnet contains a half-mile of wire about the diameter of a sewing thread. The wire is a nobium-zirconium base alloy of these two superconducting metals. About 5000 turns of the threadlike wire are wound into a coil, or solenoid, two inches in diameter, one and one-half inches long, and with a "hole in the doughnut" of one-half inch.

The coil is immersed in a vessel of liquid helium which keeps it at a temperature near –450 degrees F. The energy required to cool the coil is only a small fraction of that needed to create a comparable magnetic field with a standard electromagnet. Although only three times the thickness of a human hair, the wire from which the coil is wound carries a current of 20 amperes. At this current density, a scaled-up wire the thickness of a piece of chalk (one square centimeter) could carry 200,000 amperes.

REMOTE READING SURVEY METER INTRODUCED BY LIONEL CORP

In line with the current interest in Civil Defense, the Lionel Corporation, has placed on the market a novel radiation measuring instrument which is expected to find wide use by home owners. It is capable of measuring radiation intensity, following an atomic blast, not only inside the fallout shelter but also, by remote control, at various places inside the house and in the open at a distance from the house.

Made by one of Lionel's subsidiaries, the Lionel Electronic Laboratories, Inc., in Brooklyn, and labeled a "Home Owners' Radiation Meter", this new instrument has a selector switch to connect it successively to remotely placed radiation detectors in order to read radiation intensity in places such as the living room, kitchen, or outside the house, in addition to the shelter itself.

The scientific breakthrough represented by this instrument lies in the fact that it does not have to be re-calibrated for lead wires of differing lengths. It will read accurately for leads varying from a few to a thousand feet.

The leads can also be unplugged, and the user can carry the small, portable, battery-operated instrument around with him when he leaves the shelter.

Westinghouse Elec. Co.
Plane carries airborne TV to thousands of students in six states.

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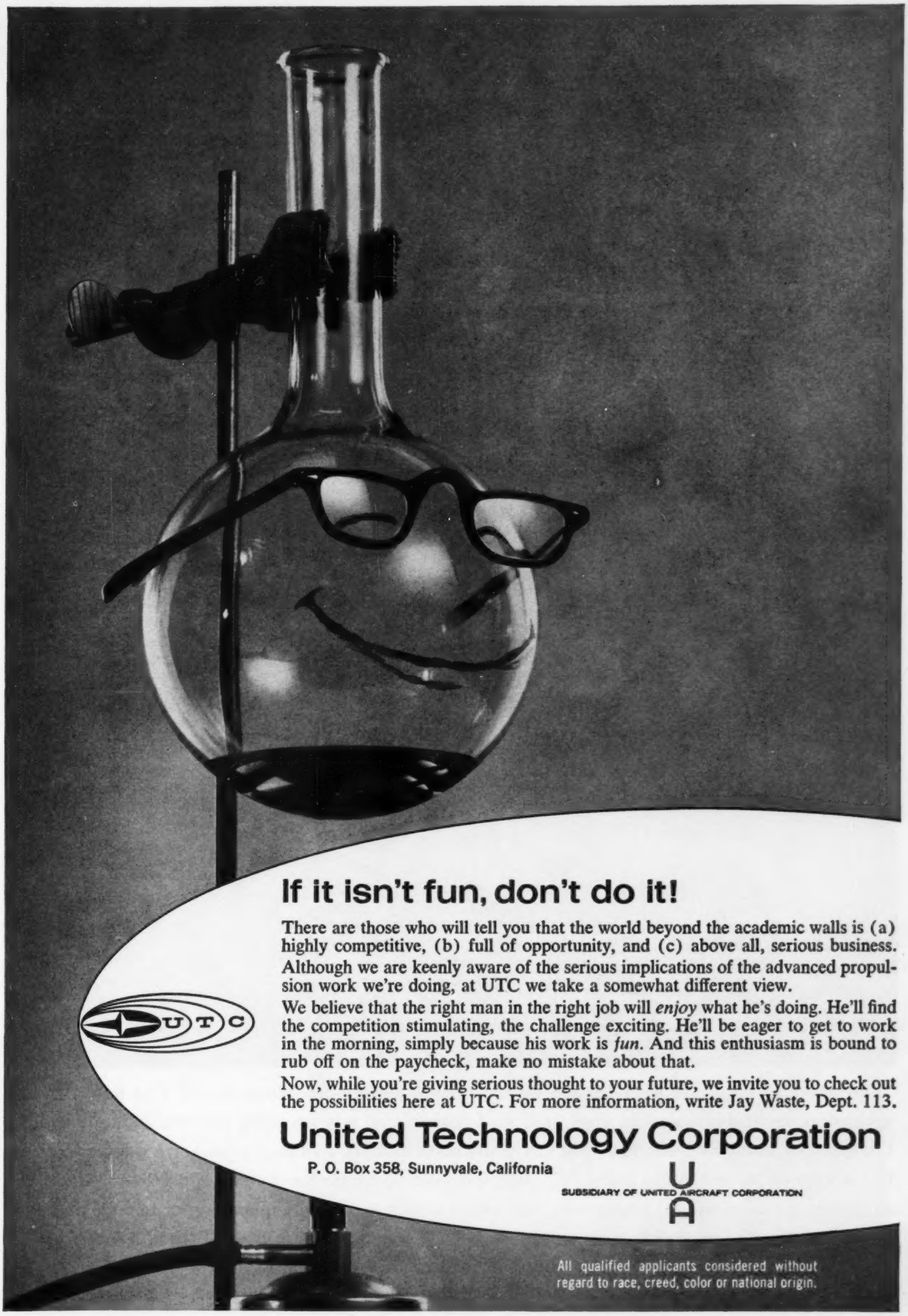
Superconducting magnet creates field intensities never before possible.


If it isn't fun, don't do it!
There are those who will tell you that the world beyond the academic walls is (a) highly competitive, (b) full of opportunity, and (c) above all, serious business. Although we are keenly aware of the serious implications of the advanced propulsion work we're doing, at UTC we take a somewhat different view.
We believe that the right man in the right job will *enjoy* what he's doing. He'll find the competition stimulating, the challenge exciting. He'll be eager to get to work in the morning, simply because his work is *fun*. And this enthusiasm is bound to rub off on the paycheck, make no mistake about that.
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FIFTY YEARS AGO IN THE ENGINEER

Edited by Alan L. Goodman, EP '64

At the First Intercollegiate Glider Meet held by the Harvard Aeronautical Society at Squantum, Mass., last June, the Cornell Aero Club's Glider No. 2 came off with honors. [The pilot] succeeded in bettering his record at Squantum by making a flight 600 feet long and attaining an altitude of 50 feet. [The glider, towed by an automobile, reached speeds between 25 and 35 miles per hour.]

The technical student should learn thoroughly and at an early date the value of systemization. Systematic methods are essential features in the daily work of engineers and other professional and business men. Imagine the confusion and inefficiency that would result if a busy engineer were to leave data and notes strewn around in every corner, no regard being paid to arrangement and order. An engineer often wishes to know certain facts at a moment's notice. If he is a wide awake and modern engineer, he will have his records and references so systematized, that he may refer to them without loss of time and patience. He will have a place for everything and everything in its place.

Most men, whatever profession they may follow, unconsciously perform their daily tasks somewhat systematically. In many cases this system is simply habit, that has been shaped by the personal tastes of the individual. By use of a little thought, this system could be replaced by a more efficient, simpler and more convenient one.

Because of the important part that system will play in their later life, students in technical schools should give thought to this matter. They should overcome the attitude of doing things simply by habit, and have a definite idea regarding the benefits to be derived from doing things in the proper way.

For instance, lecture notes and reports, curves, and other data which are collected during the college course should be filed and indexed. Numerous pamphlets, technicals and bits of valuable information may be included. Much of this may be filed in ordinary letter indices or if too bulky, by means of a card index. Complete files of technical journals may be conveniently bound for ready reference.

A daily calendar or the familiar student "Memidex" is an excellent preventative against worry and forgetfulness. Dates when reports are due, engagements, etc., may be noted under the proper date in the calendar, in a systematic way. This sort of a system promotes careful methods, promptness and reliability.

Loose papers and disorderly desks are indications of looseness and other characteristics, that the successful engineer must be free from. The student, who conducts his affairs on a systematic basis, realizing its value and thoughtfully endeavoring to develop it, has taken a long step toward insuring future success.

In preparation for the intercollege race a dual cross country race was held between M.E. and C.E. on November 21st. This was won by C. E. with a score of 47–59. Maxon, C.E. was first.

Mr. N. Nickson Miller, formerly Assistant Engineer on the Staff of Colonel G. W. Goethals, U. S. A., Chief Engineer and Chairman of the Isthmian Canal Commission, addressed the College of Civil Engineering on December 8th, speaking on the progress of work at the Panama Canal. Mr. Miller has recently come from Panama and has quite a number of excellent photographs besides having made a thorough study of the project.

—*The Sibley Journal*,
December 1911

Start of the intercollegiate cross country race, November 25, 1911.

On the frontiers of "inner-space" . . .

SCIENCE EXPLORES THE OCEAN

by William A. Fintel, ChemE '65

If one opens a paper, magazine or scientific journal one will invariably come across the word "space," either as outer-space, space race, man in space, space administration, etc.; and yet with all eyes on outer-space, many people are unaware of the importance of the "inner-space" of the oceans. Although water covers three quarters of the earth, only a very small fraction of this vast area has been explored.

Some scientists have recognized the need for exploring the oceans and for extracting food and valuable minerals. The International Oceanographic Foundation and the Woods Hole Oceanographic Institution have been solving many mysteries and inspiring many new questions about the sea. We now know a great many singular facts about the sea, but we lack scientists and equipment to learn more of the unknown, or exploit what we do know. In a sense the sea is the last earthly frontier into which science is only now beginning to advance.

The earth's underfed population is expanding more rapidly than food supplies; there will, therefore, soon arise a need for more food. Scientists agree that the sea can provide food for many centuries. Not only are fish an edible food, but sea weed and algae are also very nutritious, and some food specialists claim even appetizing. The Japanese, for example harvest and eat sea weeds grown in shallow water fields off the ocean coasts.

The earth's supply of pure fresh water is also diminishing, consequently, the purification of salt water to obtain drinking water is advisable. This problem is particularly acute on many islands and other areas near the sea which do not have an adequate supply of fresh water. Several methods are now being experimented with, such as boiling, freezing, ion separation, and super fine filters. Scientists have constructed working units that supply drinking water, but a great deal of development work is still necessary to make the conversion more economical.

Oil is an extremely important natural resource that is feared will be very scarce in a few decades. It has been estimated that one third of all the oil remaining in the world is under water, however, in only a few areas, such as the Gulf of Mexico, are a substantial number of wells being drilled in the ocean floor.

A topic of growing interest to engineers is the number of minerals contained in sea water and on the ocean floor. For many hundreds of years people have evaporated sea water to obtain salt. Recently bromine and magnesium have also been commercially extracted from sea water.

Of even more interest than what we are doing in the way of mineral extraction from the ocean, is what we could be doing. For instance, it is known that in some areas the ocean floor is covered with manganese nodules. It is not definitely known how these nodules are formed, but they are a complex mixture of manganese, iron, nickel, cobalt and copper oxides encrusted on pieces of clay or bone. In certain areas their value is estimated to be half a million dollars per square mile.

Medical research is also looking toward the oceans. Certain sea weeds are being experimented with to ascertain what different useful drugs they contain. Squids are used by nerve specialists since they possess a very large and easily studied nerve. Porpoises are going to school to learn how to speak, or at least teach us how to communicate with them. Many scientists claim the porpoise is the most intelligent animal, other than man.

War itself is a very terrible thing, but the threat of war is a tremendous stimulus to scientific research. Just as there is a space race, there is an underwater race. The Navy is devoting large amounts of time and money to learn how to offset the reflection of sonar impulses by thermoclines, schools of fish, and layers of plankton. For example; because sonar impulses are deflected by cold layers of water or layers of plankton enemy submarines are able to hide under these. Furthermore, large fish or schools of fish often reflect sonar impulses and thus set off an ASW alarm when there really is no sub at all.

The Navy is also greatly concerned with problems of underwater communications, propulsion, and explosions. Under water maps, or charts as they are called, are necessary not only to war ships, but also to commercial liners and fishing vessels. The Navy, along with the National Coast and Geodetic Survey, has compiled extensive charts of all our coastal waters.

Seemingly unrelated to the ocean is the question: "What is inside the earth?" The earth is covered with a crust varying between seven and thirty-five miles thick. Inside this is a layer called the moho, believed to be semi-molten or of a plastic like consistency. This question concerns the ocean because here the earth's crust is the thinnest, and therefore, the shortest distance to drill lies under the ocean. Although far more difficult, the same problems are involved here as there are in drilling under water oil wells.

The subjects and problems that have been outlined represent only small jumping off points into the exploration of our "inner-space," a region little better known than outer space, and probably more important to our future growth and existence. Perhaps in several hundred years we will be advanced enough to live on other planets, but it will take all our available natural resources to establish us on other planets, and this means making full use of the resources in the ocean.

One of a series . . .

Interview with General Electric's Dr. J. H. Hollomon

Manager—General Engineering Laboratory

Society Has New Needs and Wants—Plan Your Career Accordingly

DR. HOLLOMON is responsible for General Electric's centralized, advanced engineering activities. He is also an adjunct professor of metallurgy at RPI, serves in advisory posts for four universities, and is a member of the Technical Assistance panel of President Kennedy's Scientific Advisory Committee. Long interested in emphasizing new areas of opportunity for engineers and scientists, the following highlights some of Dr. Hollomon's opinions.

Q. Dr. Hollomon, what characterizes the new needs and wants of society?

A. There are four significant changes in recent times that characterize these needs and wants.

1. The increases in the number of people who live in cities: the accompanying need is for adequate control of air pollution, elimination of transportation bottlenecks, slum clearance, and adequate water resources.

2. The shift in our economy from agriculture and manufacturing to "services": today less than half our working population produces the food and goods for the remainder. Education, health, and recreation are new needs. They require a new information technology to eliminate the drudgery of routine mental tasks as our electrical technology eliminated routine physical drudgery.

3. The continued need for national defense and for arms reduction: the majority of our technical resources is concerned with research and development for military purposes. But increasingly, we must look to new technical means for detection and control.

4. The arising expectations of the peoples of the newly developing nations: here the "haves" of our society must provide the industry and the tools for the "have-nots" of the new countries if they are to share the advantages of modern technology. It is now clearly recognized by all that Western technology is capable of furnishing the material goods of modern life to the billions of people of the world rather than only to the millions in the West.

We see in these new wants, prospects for General Electric's future growth and contribution.

Q. Could you give us some examples?

A. We are investigating techniques for the control and measurement of air and water pollution which will be applicable not only to cities, but to individual households. We have developed, for example, new methods of purifying salt water and specific techniques for determining impurities in polluted air. General Electric is increasing its international business by furnishing power generating and transportation equipment for Africa, South America, and Southern Asia.

We are looking for other products that would be helpful to these areas to develop their economy and to improve their way of life. We can develop new information systems, new ways of storing and retrieving information, or handling it in computers. We can design new devices that do some of the thinking functions of men, that will make education more effective and perhaps contribute substantially to reducing the cost of medical treatment. We can design new devices for more efficient "paper handling" in the service industries.

Q. If I want to be a part of this new activity, how should I plan my career?

A. First of all, recognize that the meeting of needs and wants of society with products and services is most important and satisfying work. Today this activity requires not only knowledge of science and technology but also of economics, sociology and the best of the past as learned from the liberal arts. To do the engineering involved requires, at least for young men, the most varied experience possible. This means working at a number of different jobs involving different science and technology and different products. This kind of experience for engineers is one of the best means of learning how to conceive and design—how to be able to meet the changing requirements of the times.

For scientists, look to those new fields in biology, biophysics, information, and power generation that afford the most challenge in understanding the world in which we live.

But above all else, the science explosion of the last several decades means that the tools you will use as an engineer or as a scientist and the knowledge involved will change during your lifetime. Thus, you must be in a position to continue your education, either on your own or in courses at universities or in special courses sponsored by the company for which you work.

Q. Does General Electric offer these advantages to a young scientist or engineer?

A. General Electric is a large diversified company in which young men have the opportunity of working on a variety of problems with experienced people at the forefront of science and technology. There are a number of laboratories where research and advanced development is and has been traditional. The Company offers incentives for graduate studies, as well as a number of educational programs with expert and experienced teachers. Talk to your placement officers and members of your faculty. I hope you will plan to meet our representative when he visits the campus.

A recent address by Dr. Hollomon entitled "Engineering's Great Challenge — the 1960's," will be of interest to most Juniors, Seniors, and Graduate Students. It's available by addressing your request to: Dr. J. H. Hollomon, Section 699-2, General Electric Company, Schenectady 5, N.Y.

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All applicants will receive consideration for employment without regard to race, creed, color, or national origin.